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NR. 9. J. P. JACOBSEN AND A. C. JOHANSEN: ON THE CAUSES OF THE FLUCTUATIONS IN THE YIELD OF SOME OF OUR FISHERIES.
II. THE EEL FISHERIES.

KØBENHAVN
C. A. REITZEL, BOGHANDEL
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1922

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BIND VI

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MEDDELELSER FRA KOMMISSIONEN FOR HAVUNDERSØGELSER
SERIE: FISKERI · BIND VI · NR. 9 · 1922

ON THE CAUSES OF THE FLUCTUATIONS IN THE YIELD OF SOME OF OUR FISHERIES

II. THE EEL FISHERIES

BY

DR. J. P. JACOBSEN AND DR. A. C. JOHANSEN

KØBENHAVN
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A. Introduction.

The eel fishery is one of the most important in Denmark, and especially so at the sheltered coasts of our inner waters; it is also practised in nearly all our rivulets and lakes. It is a fairly constant fishery having been carried on at almost a uniform rate during the different years. A considerable development in the fishery has certainly taken place within the last 30 years, but this development has been even and gradual. With regard to the fishery in the salt and brackish waters the development has proceeded mainly along the following lines:

1. The number of weels and drift seines has much increased.
2. The weels are partly placed in deeper water and further from the coast than before.
3. Larger gears are used, partly large weels and partly pound nets.

In spite of the constancy in the way of fishing and in the gradual development in the intensity of fishing, we notice considerable yearly changes in the yield. The causes of these changes are on the whole unknown or at any rate insufficiently demonstrated. The probable causes of the fluctuations of which the fishermen are aware, are, as a rule, of a local character, such as the more or less favourable currents and winds in the moonless time in autumn, during which the main capture of the silver eels takes place. — Sometimes the opinion is pronounced, that the eel fishery gives the greatest yield in warm summers, whilst in certain places e. g. at Bornholm and in the West Jutland, the opinion is announced with great decision that the silver eel fishery gives the least yield in dry summers.

The view that the eel fishery should give a greater yield in warm than in cold summers, has been stated several times in the Danish literature.

In his treatise: »The yield of the Limfjord fisheries in recent years«[1]) C. G. Joh. Petersen makes a comparison between the capture of plaice and the capture of eel in the Limfjord, and he thus arrives at the result that in the years when the yield of one of these species is small, it is great of the other species. As an explanation of this phenomenon Dr. Petersen makes the following remarks:

»These two fisheries thus supplement one another, which may be considered as partly due to the fact that westerly winds during the spring and summer with westerly current and low temperatures are advantageous for the immigration of the plaice and not harmful to their growth, whilst the eel requires warm summers to grow rapidly; but at the same time this effect is most probably also increased by the fact, that the fishermen in the good eel years keep mostly to the eel fishery and thus lay less stress on the plaice fishery, while the reverse is the case in the good plaice years«.

C. V. Otterstrøm[2]) makes in his description of Danish Fishes the following remarks amongst others concerning the eel fishery: »In hot summers the eel increases most rapidly in growth here, and the silver eel fishery also appears to be greatest after hot summers«.

[1]) Report XVIII of the Danish Biological Station, Copenhagen 1909.

[2]) C. V. Otterstrøm: Danmarks Fauna 15. Fisk II Blødfinnefisk. København 1914. p. 332.

In »Dansk Fiskeritidende« No. 47 of November 23. 1915 DUEHOLM maintains that in the years in which the early summer is warm, the yield of the silver eel fishery in autumn will be proportionally great. Dueholm tries to prove the correctness of his opinion by comparing the curve of the average temperature of the air in May, June and July during the period 1905—14 with the curve representing the yearly yield of silver eels in the same period.

Dueholm's curves seem to show in the main features an accordance between the temperature and the yield, but in certain respects they are evidently not in agreement. Whilst the summer temperature is falling from 1905 to 1906 the yield increases considerably, and whilst we notice a gradual fall in the summer temperature for the years 1910—1913, we see a constant increase in the yield during this period. Concerning these incongruities Dueholm writes as follows:

»The lesser incongruities which we notice in a closer examination, may surely — if we do not take chance circumstances etc. into consideration — be explained partly by a proper knowledge of the »gear-coefficient«, the temperature, direction and force of the wind, the weather and phase of the moon in the months of capture, September and October«.

The views set forth here by PETERSEN, OTTERSTRØM and DUEHOLM will be more closely examined in this paper. We shall carry out an investigation of the relation between the temperature and the total capture of eels in the Danish waters, and at the same time we shall consider the question whether the temperature has any influence on the capture of silver eels as well as of yellow eels.

B. On the influence of temperature upon the fluctuations in the catch of silver eels and yellow eels.

The survey of the yield given here in the Tables 1 and 2 is taken from the official Danish »Fiskeri-Beretning«. In a few cases, where misprints, errors in summing up, etc. have occurred we have been able to make corrections in the original figures. We distinguish between the following areas[1]): (Fig. 1)

1. The Limfiord.
2. The East coast of Jutland from the Skaw to Hasenöre.
3. The Isefiord.
4. The Belt Sea.
5. The Sound.
6. Bornholm.

The statistics concerning the catch of eels can be followed back to 1896 with regard to the Limfiord[2]) and to 1885 for the rest of the areas mentioned. We do not carry our investigation beyond the year 1916 owing to a great scarcity of gears for the capture of eels (and other fish species) which was felt in this country during the years 1917—1919 as a consequence of the war.

In order to compare the statistics for the areas in question we have used the observations of the surface temperature[3]) which are published in »Nautisk Meteorologisk Aarbog«, a mean figure being

[1]) The catch of eels in Ringkøbing Fiord will be mentioned in Chapter D.

[2]) Statistics concerning the value of the catch for the Limfiord can be followed back to 1890.

[3]) When DUEHOLM has made a comparison between the temperature of the air and the catch of the silver eels we have no important objection. In summer there is a considerable accordance between the temperature of the air and the temperature of the shallow parts of our fresh waters as well as of our brackish fiord and coastal waters, where the eel especially lives. As we have numerous observations available concerning the temperature of the surface water at our coasts, and as it is a fact that rather considerable differences between the temperature of the air and the temperature of the surface water in early summer may appear in certain places and at certain times, we have thought it right to use the observations of the surface temperature of the water.

calculated for the temperature so that these mean figures may be said to represent as well as possible the temperature inside the given area. The stations which were chosen for the determination of the mean figures are stated in Table 3 (p. 8—9).

Our first problem is to investigate the correlation between the summer temperature and the total catch of eels in the Danish waters East of the Skaw together with the Limfiord in the years 1896—1916 (see Table 1).

Fig. 1. The Danish Waters with the principal Localities mentioned in the present paper.

We calculate the correlation between the catch anomaly per cent[1]) and the temperature anomaly, regarding the temperature of the surface water in May—September at the stations marked on Table 3. In this way we obtain the following values:

$$r = 0.694;\ \sigma_r = 0.113;\ \frac{r}{\sigma_r} = 6.1.$$

It will thus be seen, that undoubtedly a connection exists between the temperature and the total yield, and that the yield becomes greatest when the summer temperature is highest.

Table 1. Total Danish catch of Eels in the Limfjord, Kattegat, Sound and Belt Sea in the years 1896—1916, adjusted values for catch, the catch anomaly per cents for each year, the mean temperature and the temperature anomalies for the surface water for the months May—September.

Year	Catch in tons	Catch adjusted	Catch anomaly %	Mean temperature May—Septbr.	Temperature anomaly May—Septbr.
1896	2259	2190	3	15.2	1.0
1897	2413	2190	10	14.9	0.7
1898	1694	2200	—23	13.3	— 0.9
1899	2299	2210	4	14.4	0.3
1900	2468	2230	11	14.3	0.1
1901	2904	2260	28	15.1	0.9
1902	2267	2300	— 1	12.8	— 1.4
1903	2212	2380	— 7	13.6	— 0.5
1904	2535	2480	2	13.8	— 0.3
1905	2835	2600	9	14.6	0.4
1906	2890	2740	5	14.7	0.5
1907	2656	2910	— 9	12.7	— 1.5
1908	3125	3090	1	14.2	0.0
1909	2568	3290	—22	12.9	— 1.3
1910	3377	3510	— 4	15.0	0.8
1911	4240	3730	14	15.1	0.9
1912	4550	3980	14	14.0	— 0.2
1913	4564	4240	8	14.4	0.2
1914	5368	4490	20	15.5	1.3
1915	4080	4780	—15	13.8	— 0.4
1916	3586	5080	—29	13.6	— 0.5
Sum	64890	64880	19	Mean 14.2	0.1

$$r = 0.694;\ \sigma_r = 0.113;\ \frac{r}{\sigma_r} = 6.1.$$

The mean temperatures are taken by Skagens Rev, Læsø Trindel, Læsø Rende, Anholt Knob, Schultz's Grund, Lappegrunden, Drogden, Oddesund, Aalborg, Middelfart, Sprogø, Frederikssund, Madsnedø.

The above calculation does not tell us whether the great yield in hot summers is due to an increase in the quantity of silver eels or to an increase of yellow eels, or to an increase of both kinds of eels. The Danish fishery statistics are however fortunately specialized in such a way that it is possible to investigate this matter further. In the period 1885—1901 we distinguish in the statistics between:

1. Eel captured in weels and with hook and spear.
2. — — - seines.

In the period from 1902 and onwards we distinguish between:

[1]) By the catch anomaly per cent we understand the percentage which the difference between the observed yield and the normal yield makes out of the normal yield. With regard to the method of calculating the correlation coefficient see J. P. Jacobsen & A. C. Johansen: On the causes of the fluctuations in the yield of some of our Fisheries. I. The Salmon and Sea Trout Fisheries p. 7—12.

1. Eel captured in weels and pound nets.
2. Eel captured in seines.
3. — — with hook and spear.

It is a well-known fact that the vast majority of the eels captured in weels are silver eels, whilst the yellow eels are mainly captured by seines, hooks and spears. For the period after 1902 good material is at hand for the distinction between the silver eels and the yellow eels. We will now examine the connection between the summer temperature and the yield of eels caught by each sort of fishing gear in the period 1902—16. (See Table 2 and Table 3). By means of a correlation calculation we arrive at the following result:

1. Eels caught in weels 1902—1916; the catch anomaly per cent correlated with the temperature anomaly for May—September:

$$r = 0.790,\ \sigma_r = 0.097,$$

$$\frac{r}{\sigma_r} = 8.1.$$

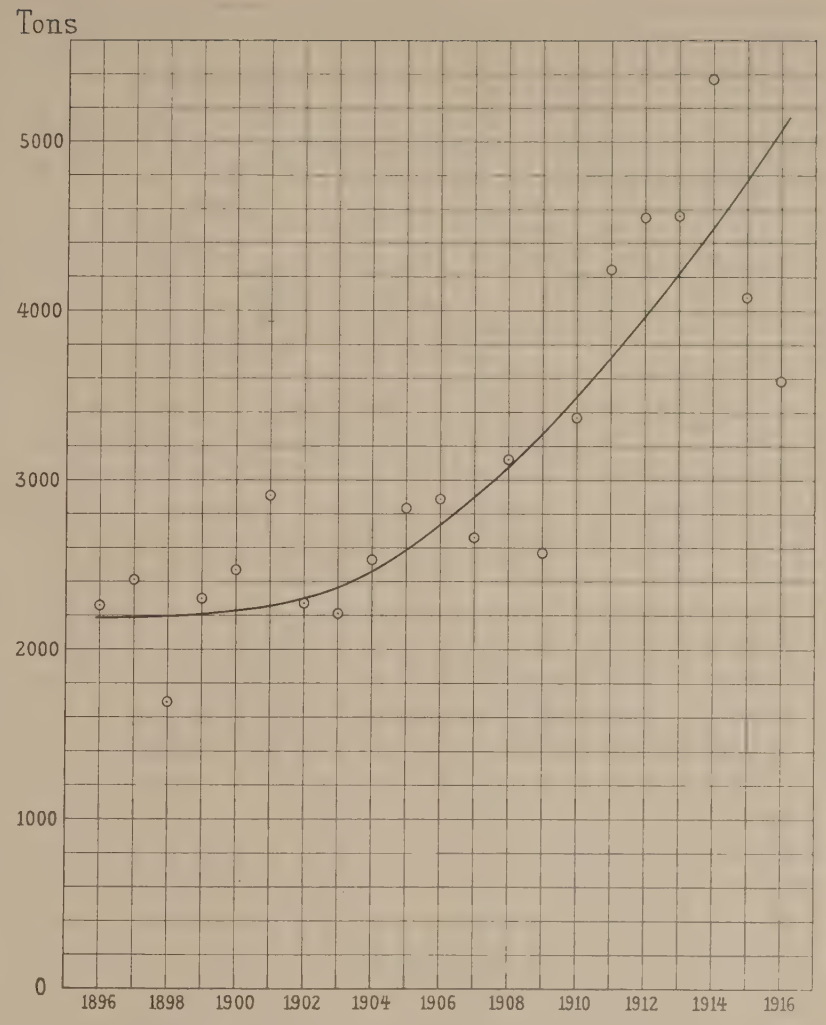

Fig. 2. Total Quantity of Eels caught in Danish waters (District 1—6, see Table 2) by various fishing apparatus in 1896—1916. The smoothed curve represents the »normal yield«.

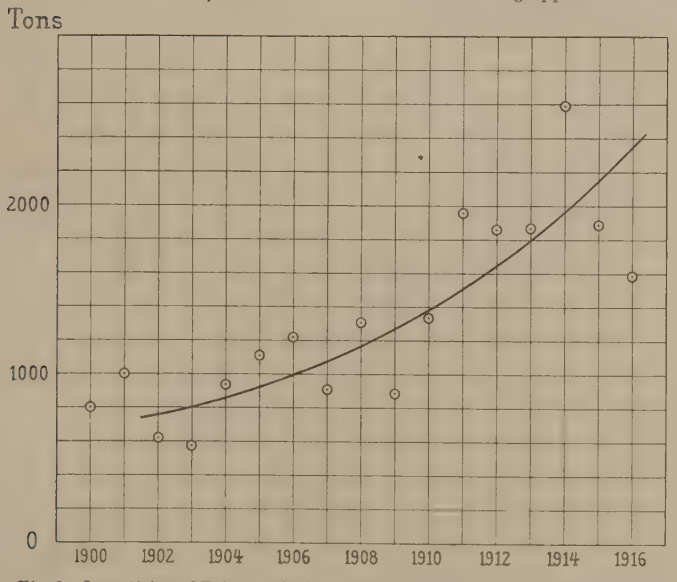

Fig. 3. Quantities of Eels caught in weels in Danish Waters (District 1—6, see Table 2) in 1900—1916. The smoothed curve represents the »normal yield«.

2 Eels caught in seines 1902—1916; the catch anomaly per cent correlated with the temperature anomaly for May—August:

$$r = 0.561,\ \sigma_r = 0.177,$$

$$\frac{r}{\sigma_r} = 3.2.$$

3. Eels caught by hook and spear 1902—1916; the catch anomaly per cent correlated with the temperature anomaly for May—August:

$$r = 0.081,\ \sigma_r = 0.256,$$

$$\frac{r}{\sigma_r} = 0.3$$

This analysis shows that there is a connection between the temperature and the catch of weel caught eels as well as of seine

Table 2. Catch of Eels by Weels, Seines, Hooks and Spears in the years 1902—1916 for various Danish coastal areas; øre (Grenaa included). 3. Isefiord (Lynæs—Tisvilde incl.). 4. The Belt Sea (northern limit: Hasenøre—Gniben, eastern included). 5. The Sound (Gilleleje, Køge Bugt and the stretch Køge—

Year	Catch in Tons												Catch					
	Weels							Seines				Hooks & Spear	Weels					
	1	2	3	4	5	6	7	1	3	4	7	7	1	2	3	4	5	7
1902	126	43	26	351	76	1.6	623	404	97	461	1042	602	100	36	26	380	70	760
1903	68	35	38	375	65	0.7	583	319	105	553	1006	622	120	39	30	420	80	810
1904	171	62	46	554	106	1.8	940	387	104	484	1036	558	140	42	34	470	100	870
1905	260	26	51	648	125	0.6	1111	503	85	526	1169	554	160	45	38	520	120	930
1906	242	58	81	628	211	3.4	1224	538	78	518	1175	491	180	48	43	570	140	1000
1907	203	56	43	506	104	1.1	913	498	90	492	1092	652	200	51	48	620	170	1080
1908	209	69	70	685	270	1.0	1305	434	83	647	1198	622	220	54	54	680	200	1170
1909	128	32	26	581	116	3.5	885	310	70	567	1031	652	240	57	60	730	240	1260
1910	282	75	35	721	223	3.9	1339	410	119	799	1366	673	260	60	67	790	270	1380
1911	307	75	62	1056	455	2.7	1958	454	110	707	1357	925	280	63	75	840	310	1500
1912	358	64	64	911	464	—	1860	635	87	728	1611	1079	310	66	83	900	360	1650
1913	331	57	136	966	367	12.6	1870	636	119	688	1612	1082	330	69	92	970	400	1800
1914	436	98	101	1281	671	9.0	2597	638	126	638	1545	1226	350	72	102	1030	450	1970
1915	293	51	106	981	454	3.8	1888	464	120	556	1218	974	380	75	112	1090	500	2160
1916	265	54	102	924	244	4.2	1593	296	93	660	1076	917	410	78	123	1160	550	2340
Sum	3679	855	987	11168	3951	50	20689	6926	1486	9024	18534	11629	3680	855	987	11170	3960	20680

Table 3. Temperature in the surface water

Year	Mean temperature														
	The whole of Denmark							Limfiord		East coast of Jutland	Belt Sea		The Sound	Isefiord	
	May-Sept.	May-Aug.	May	June	July	August	Septbr.	May-Sept.	May-Aug.	May-Sept.	May-Sept.	May-Aug.	May-Sept.	May-Sept.	May-Aug.
1902	12.8	12.8	8.2	13.7	15.3	14.0	12.6	13.2	13.5	12.5	12.8	12.8	12.2	13.2	13.3
1903	13.7	13.8	9.5	14 6	16.2	14.8	13.2	14.2	14.4	13.4	13.5	13.6	13.2	14.1	14.4
1904	13.9	13.8	9.0	14.1	15.8	16.3	14.2	14.3	14.4	13.6	13.8	13.7	13.5	14.4	14.4
1905	14.6	14.8	9.5	15.4	17.7	16.6	13.9	15.2	15.8	14.2	14.6	14.8	14.2	15.1	15.4
1906	14.7	14.8	10.7	15.5	16.4	16.7	14.3	15.1	15.3	14.2	14.7	14.8	14.3	15.4	15.6
1907	12.7	12.6	8.8	12.5	15.0	14.3	13.0	13.1	13.3	12.3	12.7	12.6	12.5	13.3	13.2
1908	14.2	14.4	8.7	14.4	18.0	16.7	13.4	14.6	15.0	13.8	14.1	14.4	14.0	14.8	15.2
1909	13.0	12.8	8.0	12.9	15.5	14 9	13.5	13.4	13.5	12.5	13.0	12.9	12.5	13.6	13.5
1910	15.0	15.0	10.2	15.7	17.2	17.1	14.8	15.7	16.0	14.6	14.8	14.8	14.6	15.4	15.5
1911	15.1	15.2	11.0	15.0	16.1	18.5	14.9	15.7	16.0	14.7	14.9	14.8	14.7	15.7	15.9
1912	14.0	14.3	9.6	13.3	18.0	16.3	12.8	14.2	14.7	13.7	13.9	14.2	13.7	14.5	15.0
1913	14.4	14.2	10.3	14.0	16.5	16.2	15.0	14.8	14.9	13.9	14.3	14.1	13,9	15.0	15.0
1914	15.5	15.6	10.5	14.7	19.2	18.0	15.3	15.8	16.1	15 1	15.5	15.5	15.2	16.1	16.3
1915	13.8	13.7	9.2	13.8	15.7	16.2	14.2	14.3	14.4	13.3	13.8	13.8	13.7	14.4	14.4
1916	13.7	13.6	10.0	12.3	16.3	16.0	13.9	14.0	14.2	13.3	13.7	13.6	13.4	14.3	14.3
Mean	14.1	14.1	9.5	14.1	16.6	16.2	13.9	14.5	14.8	13.7	14.0	14.0	13.7	14.6	14.8

The whole of Denmark.

Skagens Rev
Læsø Trindel
Læsø Rende
Anholt Knob
Schultz's Grund
Lappegrunden
Drogden
Oddesund
Aalborg
Middelfart
Kalundborg Fjord (Kysthospitalet)
Sprogø
Frederikssund
Masnedø
Rørvig
København (Middelgr.

The Limfiord.

Oddesund
Aalborg

East Coast of Jutland.

Skagens Rev
Læsø Rende
Schultz's Grund
Middelfart

adjusted values and catch anomaly per cents 1. Limfiord. 2. East Coast of Jutland from Skagen (the Skaw) to Hasenlimit: Gjedser—Darserort; the stretch from Mandehoved to Kallehave and Møen included, east coast of Slesvig not Sønakke-Mandehoved included). 6. Bornholm. 7. Total areas 1–6.

adjusted					Catch anomaly per cents										
Seines				Hooks & Spear	Weels						Seines				Hooks & Spear
1	3	4	7	7	1	2	3	4	5	7	1	3	4	7	7
390	92	480	1060	550	30	19	0	— 8	14	—18	3	5	— 4	— 2	9
400	93	490	1060	550	—42	—10	27	—10	—12	—28	—20	13	12	— 5	13
410	94	510	1070	550	21	48	35	17	10	8	— 5	11	— 6	— 3	2
420	94	520	1090	560	62	—42	34	25	8	19	19	—10	2	7	— 2
430	95	530	1110	570	33	21	88	11	50	22	26	—18	— 2	5	—14
440	96	550	1140	590	0	10	—10	—18	—41	—16	14	— 6	—11	— 4	10
450	97	560	1170	630	— 5	28	30	1	35	11	— 4	—14	16	3	— 2
460	9[illegible]	580	1210	680	—46	—44	—57	—21	—50	—29	—33	—29	— 2	—15	— 4
470	99	600	1250	750	8	25	—48	— 9	—19	— 3	—13	20	33	10	—11
480	100	630	1290	820	11	19	—17	26	48	31	— 6	10	13	5	13
490	101	660	1330	900	16	— 3	—23	1	28	13	31	—14	11	21	20
500	103	680	1370	980	0	—17	48	0	— 8	4	28	16	1	18	10
520	106	710	1420	1070	26	36	— 1	24	49	32	23	19	—10	8	15
530	108	750	1460	1160	—24	—32	— 5	—10	—10	—12	—13	11	—25	—16	—16
540	110	790	1510	1260	—37	—31	— 17	—21	—56	—32	—44	— 15	—16	—28	—27
6930	1486	9040	18540	11620	+53	+27	+84	+ 8	+46	+ 2	+ 6	— 1	+12	+ 4	+16

at the Danish coasts in the years 1902—1916.

Temperature anomalies C.														
The whole of Denmark							Limfiord		East coast of Jutland	Belt Sea		The Sound	Isefiord	
May-Sept	May-Aug.	May	June	July	August	Septbr.	May-Sept.	May-Aug.	May-Sept.	May-Sept.	May-Aug.	May-Sept.	May-Sept.	May-Aug.
—1.3	—1.3	—1.3	—0.4	—1.3	—2.2	—1.3	—1.3	- 1.3	—1.2	—1.2	—1.2	—1.5	—1.4	—1.5
—0.4	—0.3	0.0	0.5	—0 4	—1.4	—0.7	—0.3	- 0.4	—0.3	—0.5	—0.4	—0.5	—0.5	—0 4
- 0.2	—0.3	—0.5	0.0	—0.8	0.1	0.3	—0.2	—0.4	- 0.1	—0.2	—0 3	—0.2	—0.2	—0.4
0.5	0.7	0.0	1.3	1.1	0.4	0.0	0.7	1.0	0.5	0.6	0 8	0 5	0.5	0.6
0.6	0.7	1.2	1.4	0 2	0.5	0.4	0.6	0.5	0.5	0.7	0.8	0.6	0.8	0.8
—1.4	—1.5	—0.7	—1 6	—1.6	—1.9	— 0.9	—1.4	—1.5	—1.4	—1.3	—1.4	—1.2	—1.3	—1.6
0.1	0.3	—0.8	0.3	1.4	0.5	—0.5	0.1	0.2	0.1	0.1	0.4	0.3	0.2	0.4
—1.1	—1.3	—1.5	—1.2	—1.1	—1.3	—0.4	—1.1	—1.3	—1.2	—1.0	—1.1	—1.2	—1.0	- 1.3
0.9	0.9	0.7	1 6	0.6	0.9	0.9	1.2	1.2	0.9	0.8	0.8	0.9	0.8	0.7
1.0	1.1	1.5	0.9	—0.5	2.3	1.0	1.2	1.2	1.0	0.9	0.8	1.0	1.1	1.1
—0.1	0.2	0.1	—0.8	1.4	0.1	—1.1	—0.3	—0.1	0.0	—0.1	0.2	0.0	—0.1	0.2
0.3	0.1	0.8	—0.1	—0.1	0.0	1.1	0.3	0.1	0.2	0.3	0.1	0 2	0.4	0.2
1.4	1.5	1.0	0.6	2.2	1.8	1.4	1.3	1.3	1.4	1.5	1.5	1.5	1.5	1.5
—0.3	—0.4	- 0.3	—0.3	—0.9	0.0	0.3	—0.2	—0.4	—0.4	—0.2	—0.2	0.0	—0.2	—0.4
—0.4	—0.5	0.5	—1.8	—0.3	—0.2	0.0	—0.5	—0.6	—0.4	—0.3	—0.4	—0.3	—0.3	—0.5
—0.4	—0.1	0.7	0.4	—0.1	—0.4	0.5	0.1	—0.5	- 0.4	0.1	0.4	0.1	0.3	—0.6

Belt Sea.	The Sound.	Isefiord.
Schultz's Grund	Lappegrunden	Lappegrunden
Kalundborg Fjord (Kysthospitalet)	Drogden	Schultz's Grund
Sprogø	København (Middelgr.)	Rørvig
Masnedø		Frederikssund

caugt eels whilst we cannot prove any connection between the summer temperature and the eels caught by hook or spear.

The correlation obtained between the temperature and the catch of silver eels (weel caught eels) must undoubtedly be explained by the fact that increased temperature (as is the case with salmon and trout) hastens maturity. Many of the eels which in hot summers become silver eels would not in less warm summers have appeared in this dress. The great yield by weight of silver eels in hot summers is certainly due to the circumstance that more silver eels occur than normally. The silver eels are probably not larger in hot summers, perhaps even smaller than normally — like running salmon of the youngest group —. Sufficient material for a special examination of this question has however not been available.

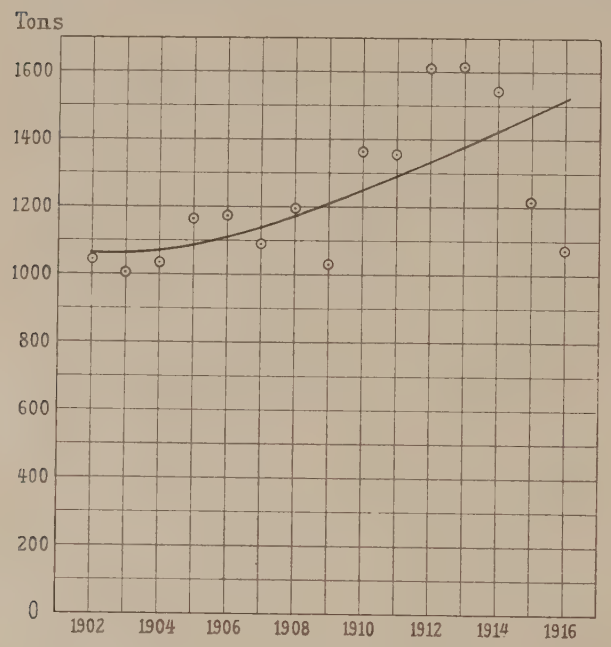

Fig. 4. Quantities of Eels caught in seines in Danish waters in 1902—16 (District 1—6, see Table 2).

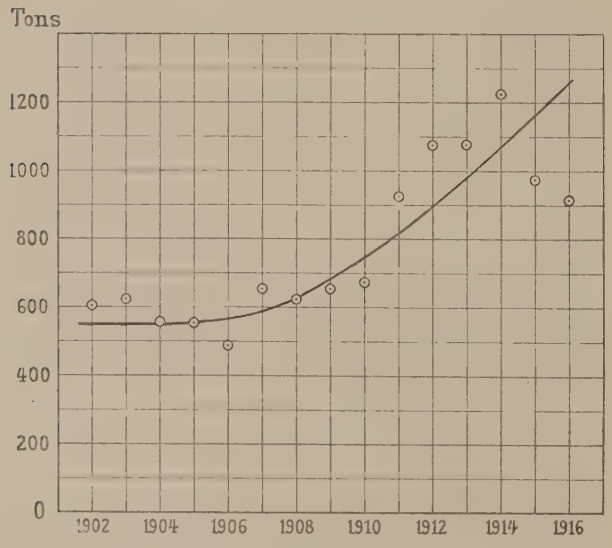

Fig. 5. Quantities of Eels caught by hooks and spear in Danish waters in 1902—16 (District 1—6, see Table 2).

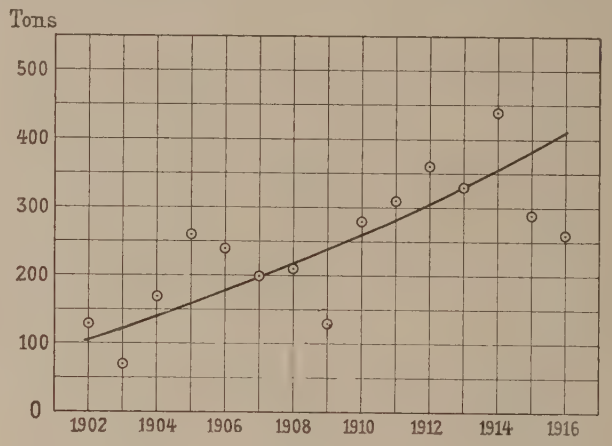

Fig. 6. Quantities of Eels caught in weels in the Limfiord in 1902—16.

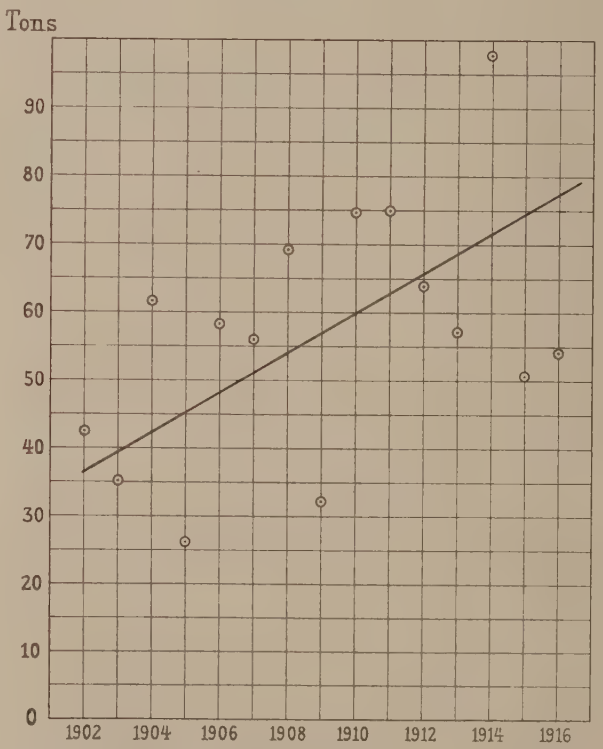

Fig. 7. Quantities of Eels caught in weels at the East-coast of Jutland in 1902—16.

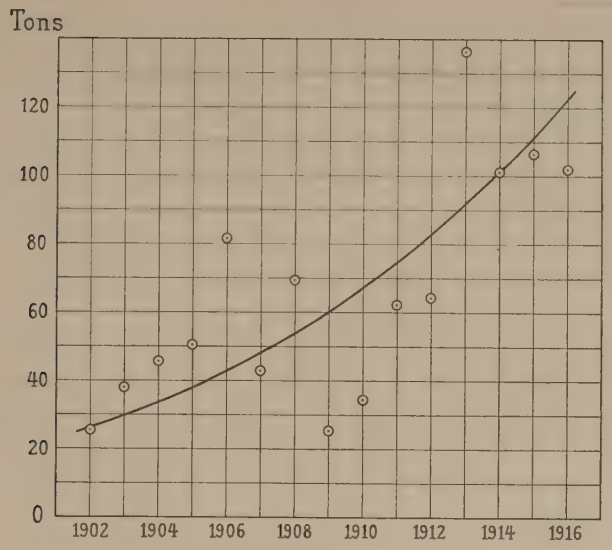

Fig. 8. Quantities of Eels caught in weels in the Isefiord in 1902—16.

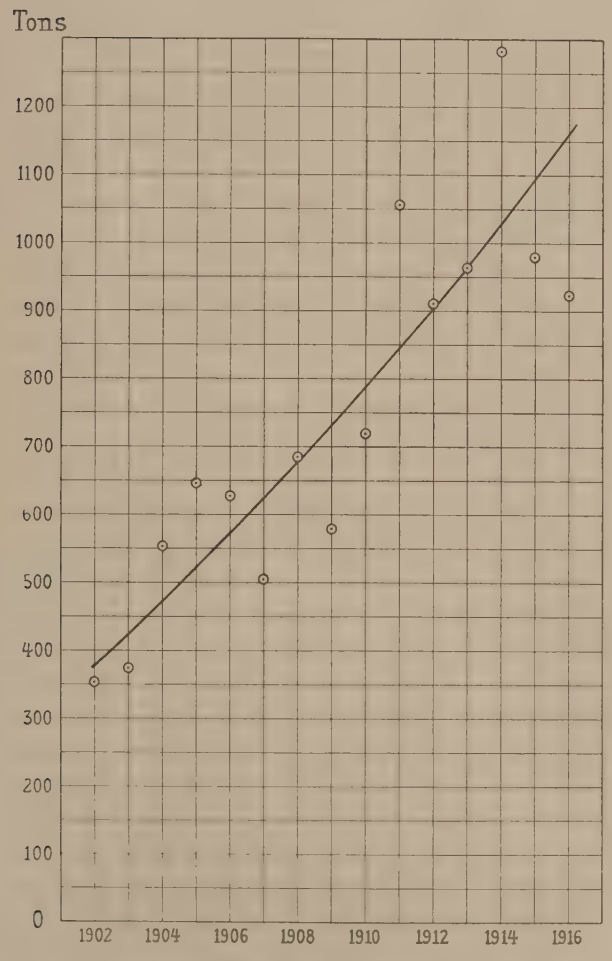

Fig. 9. Quantities of Eels caught in weels in the Belt Sea in 1902—16.

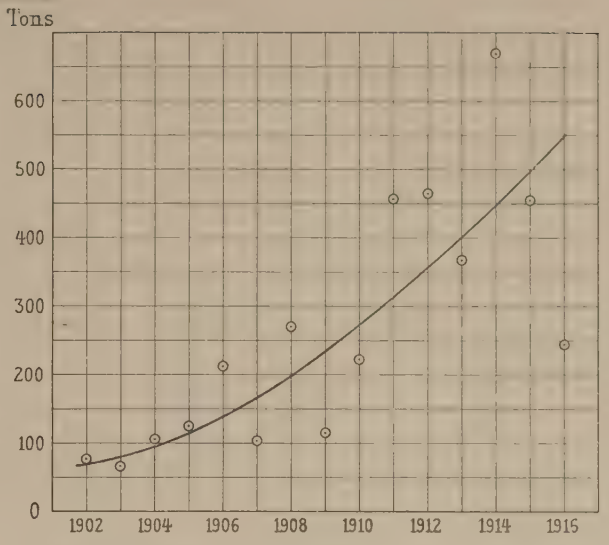

Fig. 10. Quantities of Eels caught in weels in the Sound in 1902—16.

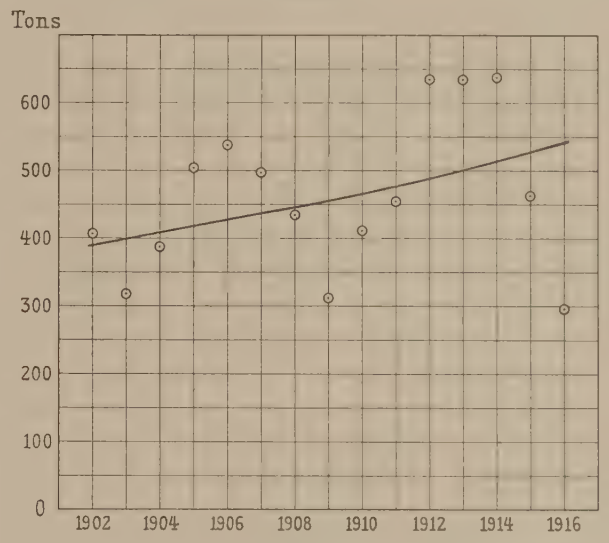

Fig. 11. Quantities of Eels caught in seines in the Limfiord in 1902—16.

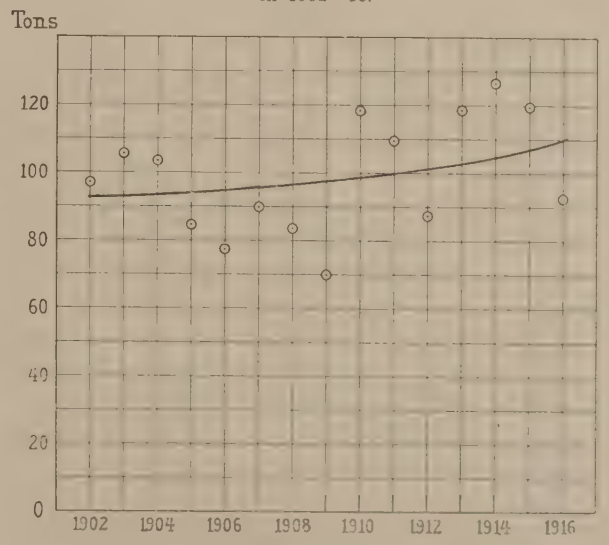

Fig. 12. Quantities of Eels caught in seines in the Isefiord in 1902—16.

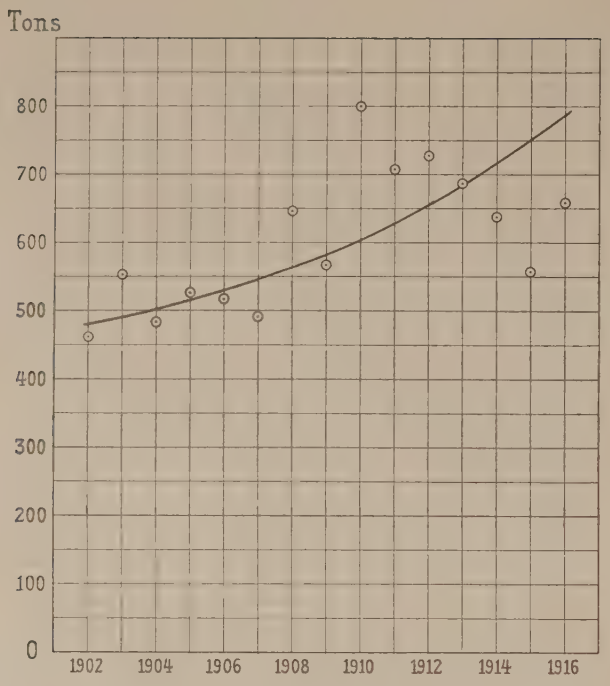

Fig. 13. Quantities of Eels caught in seines in the Belt Sea in 1902—1916.

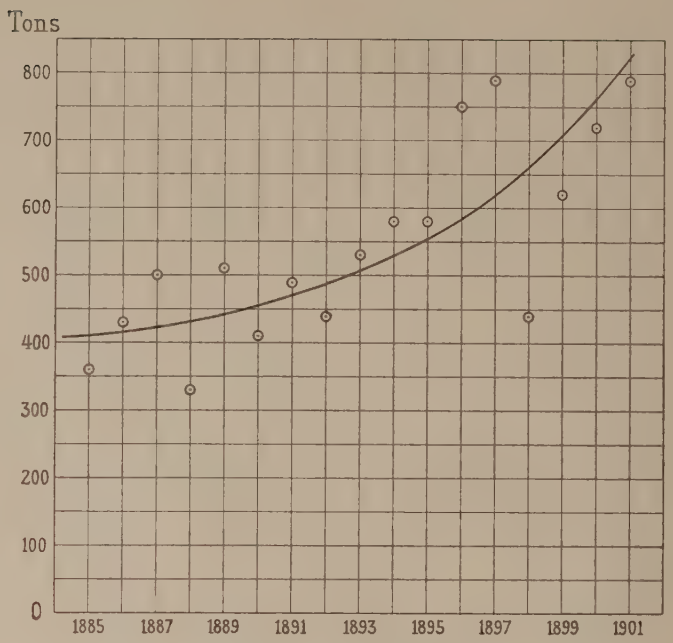

Fig. 14. Quantities of Eels caught by weels and hooks in the Belt Sea 1885—1901.

The capture of silver eels mainly takes place in the moonless nights from the middle of September till the middle of November.

According to A. C. Johansen and E. Neergaard-Möller[1]) the weel-caught eels were distributed over the various months in the Kattegat, Belt Sea and Baltic in 1910 as follows:

January	0.1 %	July	1.1 %
February	0.0 —	August	4 2 —
March	0.3 —	September	33.6 —
April	2.1 —	October	41.5 —
May	3.0 —	November	11.3 —
June	1.0 —	December	1.8 —

The question now arises, as to which period of summer a proportionately high temperature will influence the yield most intensely. In order to obtain a provisional hypothesis concerning this question we shall correlate the temperature anomalies for each month separately with the catch anomaly per cents. We thus obtain the following result, when we consider the weel-caught eels in the Danish waters (1—6) during the period 1902—1916:

Temp. anomal. corr. with catch anomaly for weel-caught eels in 1902—16:

$$\text{May} \qquad r = 0.583; \quad \sigma_r = 0.170; \quad \frac{r}{\sigma_r} = 3.4,$$

$$\text{June} \qquad r = 0.636; \quad \sigma_r = 0.154; \quad \frac{r}{\sigma_r} = 4.1,$$

$$\text{July} \qquad r = 0.620; \quad \sigma_r = 0.159; \quad \frac{r}{\sigma_r} = 3.9,$$

[1]) Biological-statistical Report on the produce of the Danish Sea Fishery in 1910. Medd. Komm. f. Havunders. Ser. Fiskeristatistik Bd. II. København 1913.

August $r = 0.801$; $\sigma_r = 0.092$; $\frac{r}{\sigma_r} = 8.7$,

September $r = 0.525$; $\sigma_r = 0.187$; $\frac{r}{\sigma_r} = 2.8$.

It will be seen that the correlation factor for the month of August is of far higher value than for the rest of the months, but that it is also positive for these months and of considerable value (Fig. 15—16).

This phenomenon that a correlation appears between the catch anomaly per cent and the temperature anomaly in May, June, July and September might however be explained by the fact that a not inconsiderable correlation exists between the August temperature and the temperature in the remainder of the summer months, so that according to these figures we should only be justified in concluding that a connection exists between the August temperature and the yield.

In order to ascertain as far as possible to what extent the temperature in each of the months influences the capture, we have investigated this dependence in the following way. We assume that the catch anomaly F may be expressed by the temperature anomalies

t_{May}, t_{June}, t_{July}, t_{August} and $t_{September}$ respectively for the months May—September by

$F = k_{May} \times t_{May} + k_{June} \times t_{June} + k_{July} \times t_{July} + k_{Aug.} \times t_{Aug.} + k_{Sep.} \times t_{Sep.}$, as k_{May}, k_{June}, k_{July}, $k_{Aug.}$ and $k_{Sept.}$

are constants with which the temperature anomalies in question should be multiplied in order to yield the catch anomaly obtained.

By the following calculations the catch and the catch anomaly was calculated with a ton as a unit and the catch anomaly per cent as the percentage which the anomaly makes of the normal catch

Table 4. Catch of Eels in the Belt Sea by means of Hooks and Weels in the years 1885—1901 correlated with the mean temperature of the surface water in May—September.

Year	Mean temperature May—September		Temperature anomaly $^1/_{20}{}^0$	Catch in Tons	Catch adjusted Tons	Catch anomaly	Catch anomaly per cent
	Schultz's Grund	Kallundborg Fjord (Kysthospital)					
1885	13.9	14.1	— 8	358	410	— 52	—13
1886	14.7	15.0	9	431	420	11	3
1887	14.0	14.0	— 8	504	420	84	20
1888	13.0	13.4	—24	333	430	— 97	—23
1889	15.7	14.9	18	506	440	66	15
1890	14.1	14.6	— 1	413	450	— 37	— 8
1891	14.1	14.3	— 4	491	470	21	4
1892	13.8	13.8	—12	436	490	— 54	—11
1893	14.8	14.0	0	531	500	31	6
1894	14.8	14.7	7	584	530	54	10
1895	14.7	15.3	12	576	550	26	5
1896	15.4	15.1	17	755	590	165	28
1897	15.0	14.5	7	785	620	165	27
1898	13.2	13 2	—24	439	660	—221	—33
1899	14.6	14.8	6	619	710	— 91	—13
1900	14.3	14.5	0	716	760	— 44	— 6
1901	15.0	14.8	10	793	820	— 27	— 3
Mean	14.4	14.4	Sum 5	9270	9270	0	8

$r = 0.712$ $\sigma_r = 0.120$ $\frac{r}{\sigma_r} = 5\,9.$

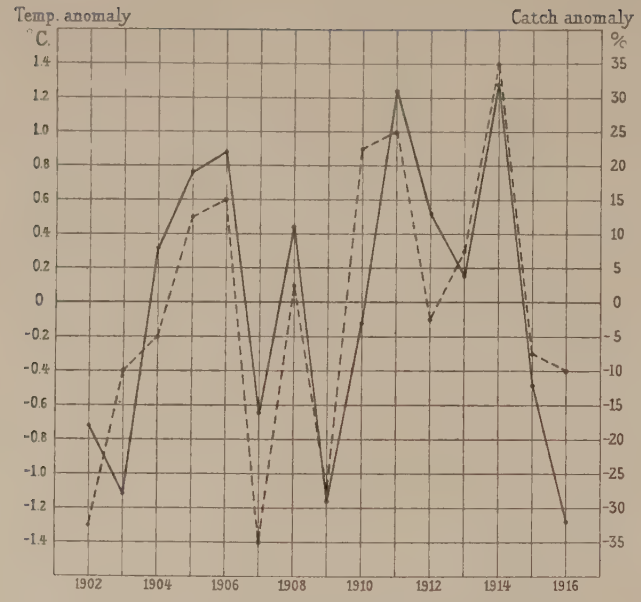

Fig. 15. Temperature anomalies for May to September (broken line) compared with catch anomaly per cent for Eels caught in weels in Danish waters. (District 1—6, Table 2).

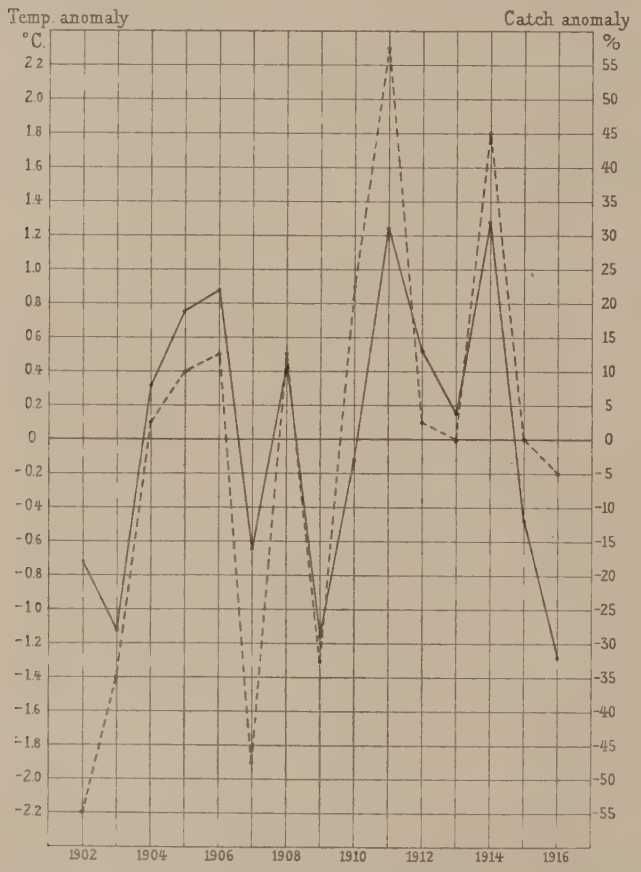

Fig. 16. Temperature anomalies for August (broken line) compared with catch anomaly per cent for Eels caught in weels in Danish waters. (District 1—6, see Table 2).

obtained by a graphical equalisation (see Fig. 2—14). The temperature anomaly is calculated in tenth degrees as deviation from the mean temperature.

The signification of the constants k_{May}, k_{June} etc. may thus be formulated as the per centage by which the normal catch will increase when the temperature in the month for which the constant applies is $^1/_{10}$ degree higher than normal.

The calculation is carried out for the available material 1902—1916 for the entire area (1—6) according to the method of least squares and has given the following result:

Constants

k_{May}	k_{June}	k_{July}	$k_{Aug.}$	$k_{Septbr.}$
—0.02	0.53	0.13	1.40	—0.65

Mean errors

k_{May}	k_{June}	k_{July}	$k_{Aug.}$	$k_{Septbr.}$
1.04	0.49	0.45	0.66	0.80

These figures show, that we may conclude with considerable certainty, that it is the August temperature — and not as presumed by Dueholm the temperature in early summer about May—July — which has the most decisive influence on the catch of silver eel. Whether the temperature in May, June, July and September has any influence on the whole with regard to the catch of silver eels cannot be said with certainty on the basis of the material at hand. The constants obtained for these months are only of about the same magnitude or still smaller than their mean error. The greater probability is however that a relatively high temperature in June and July contributes to some degree to increase the catch. The value obtained for $k_{Aug.} = 1.40$ indicates, that we must expect, that when the mean temperature for August is 1 ° C. higher than normal, then the catch of eels in weels during the autumn months will be ca. 14 % higher than normal ($\pm$ 6.6 %).

On the previous pages we have examined the correlation between the temperature anomalies and the catch anomalies for weel-caught eels for all the Danish waters east of the Skaw plus

the Limfiord. We shall now proceed to consider the correlation between the temperature anomalies in each of the above named areas separately, excepting Bornholm because the material at disposal here is too small and casual to form the basis for a correlation calculation. We thus arrive at the following result.

Temperature anomaly for May—September correlated with the catch anomalies for weel-caught eels during the period 1902—1916:

1. The Limfiord $r = 0.418$; $\sigma_r = 0.213$; $\frac{r}{\sigma_r} = 2.0$.
2. Jutland's East-Coast $r = 0.352$; $\sigma_r = 0.226$; $\frac{r}{\sigma_r} = 1.6$.
3. The Isefiord $r = 0.238$; $\sigma_r = 0.244$; $\frac{r}{\sigma_r} = 1.0$.
4. The Belt Sea $r = 0.738$; $\sigma_r = 0.118$; $\frac{r}{\sigma_r} = 6.3$.
5. The Sound $r = 0.604$; $\sigma_r = 0.164$; $\frac{r}{\sigma_r} = 3.7$.

The proportionately low value of the correlation coefficient for Jutland's East-coast suggests that no great run of silver eels takes place along this coast as it does in the Belts and in the Sound. The majority of the silver eels from the Belts and Baltic waters follow evidently the open Kattegat on their way to the Skagerak and the North Sea.

The small correlation coefficient for the Isefiord must be regarded in the light of the small catch. Causes of a casual nature may here influence the catch essentially.

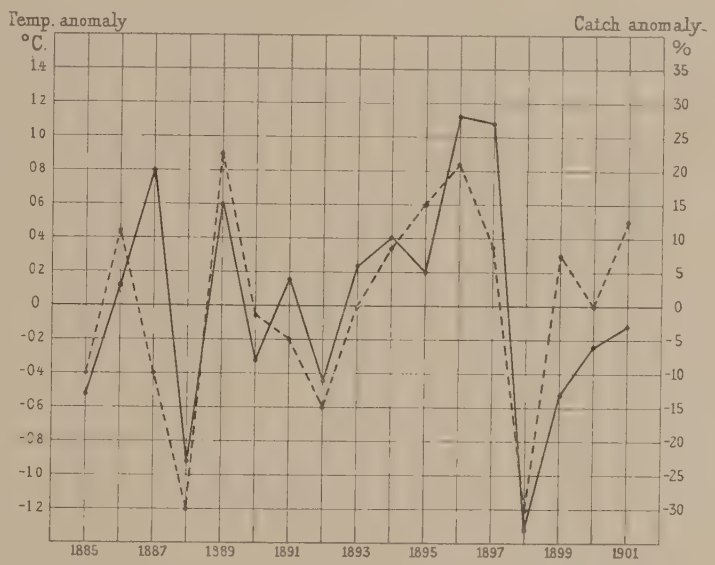

Fig. 17. Temperature anomalies for May to September (broken line) compared with catch anomaly per cent for Eels caught by weels and hooks in the Belt Sea in the years 1885—1901 (see Table 4).

The rather low value of the correlation coefficient for the Limfiord in proportion to the Sound and the Belt Sea can be explained in the following way: Among the eels which are caught in weels in the Limfiord, a proportionately large percentage consists of yellow eels. The Inspector of Fisheries Andersen has informed us that he reckons, that the silver eels does not form more than 40 % of the weight of all the weel caught eels taken in the Limfiord. The weel fishery for yellow eels in the Limfiord begins as early as in March and for silver eels not till September. Any great migration of silver eels from other waters evidently does not take place through the Limfiord.

In the period 1885—1901 the weel-caught eels were not in the statistics distinguished from the eels caught by hook and spear. In spite of this fact the correlation coefficient is however of considerable magnitude if we correlate the temperature anomaly for the summer months with the catch anomaly. But this is only natural as the catch in weels forms a very essential part of this yield. A calculation for the Belt Sea (see Table 4), our most important water for the eel fishery, gives the following result:

The temperature anomaly for May–September correlated with the catch anomaly for eels caught in weels and by hook and spear in the period 1885—1901:

$$r = 0.712; \quad \sigma_r = 0.120; \quad \frac{r}{\sigma_r} = 5.9. \text{ (see Fig. 17).}$$

The capture of eels by seines mainly takes place during the time from June to September. According to A. C. Johansen and E. Neergaard-Møller (l. c.) the seine-caught eels were distributed during the various months in 1910 in the Kattegat, Belt Sea and Baltic as follows:

January	0.2 %	July	19.5 %
February	0.3 —	August	19.4 —
March	0.3 —	September	15.7 —
April	1.1 —	October	11.6 —
May	8.5 —	November	3.8 —
June	16.6 —	December	3.0 —

According to C. F. Drechsel (Oversigt over vore Saltvandsfiskerier. 1890) the distribution of the yield of the seine fishery during the different months was as follows about 1888:

	Hand seines	Drift seines		Hand seines	Drift seines
January	0	0	July	27	28
February	0	0	August	19	14
March	0	0	September	12	7
April	1	5	October	10	5
May	9	16	November	0	2
June	22	23	December	0	0

As stated before (p. 7) we find, by the calculation of the correlation between the temperature anomalies for May—August and the catch anomalies for eel caught in seines, a value of 0.561, for r, if we consider all the Danish waters (District 1—6). If we regard the most important areas separately we obtain the following values:

Temperature anomalies for May—August correlated with catch anomalies for eel captured in seines during the period 1902—1916

The Limfiord $r = 0.325;\ \sigma_r = 0.231;\ \frac{r}{\sigma_r} = 1.4.$

The Isefiord $r = 0.295;\ \sigma_r = 0.236;\ \frac{r}{\sigma_r} = 1.3.$

The Belt Sea $r = 0.355;\ \sigma_r = 0.226;\ \frac{r}{\sigma_r} = 1.6.$

It will be seen that the values obtained for the correlation coefficient are on an average smaller, but more uniform than for the silver eels.

In a similar way as for the weel-caught eels, we have investigated whether any connection can be traced between the yield of the seine-caught eels and the deviation of the temperature from the normal value in the months May, June, July and August. The investigation has been restricted to these four months as the capture of eels in seines mainly takes place in the summer months.

In the same way as in the treatment of the problem for the silver eels we indicate the yearly percentage of the catch anomaly for the whole of Denmark by F, and as t_{May}, t_{June}, t_{July} and t_{August} indicate the temperature anomalies expressed in tenth degrees in the months indicated by indices we put

$$F = k_{May} \cdot t_{May} + k_{June} \cdot t_{June} + k_{July} \cdot t_{July} + k_{Aug.} \cdot t_{Aug.}$$

k_{May}, k_{June}, k_{July} and $k_{Aug.}$ thus indicate the constants with which the anomalies of temperature in the months in question in a certain year must be multiplied in order to express as near as possible the obtained catch anomaly percentage. A calculation of the constants on the basis of the material set forth in Table 2 and 3 by the method of least squares gave the result:

Constants				Mean errors for the constants			
k_{May},	k_{June},	k_{July},	$k_{Aug.}$	k_{May},	k_{June},	k_{July},	$k_{Aug.}$
0.317	0.443	0.566	—0.319	0.63	0.37	0.35	0.44

From this it will be seen that the constants are generally small in proportion to their mean error, but the constant for July amounts however to 1.6 times its mean error. It should also be noticed that the signs are the same for the first 3 constants. We may thus be justified in concluding that there is a great probability that a high temperature in the early summer and especially in July causes a comparatively large yield of yellow eels.

The significance of the constant k_{July}, which must be regarded as determined with greater certainty than the other ones, can be expressed so, that when the July temperature is 1° higher than normal it is to be expected that the yield in kgs of yellow eels will be 6 % higher than normal ($\pm$ 3.7 %) in the year in question.

The relatively high yield of yellow eels in hot summers can probably be partly, if not entirely, explained by the fact, that the yellow eel has a proportionately rapid growth in a high summer temperature. The variations in the yield, produced by the temperature are, however, not nearly as great as for the silver eels, and the possibility, believed by Petersen, that the influence of the temperature on the oscillations in the yield, may be intensified because the fishermen will carry on the eel fishery more assiduously in warm summers than in cold ones, is not excluded.

As stated before, it is not possible to trace any connection between the summer temperature and the yield of eels caught by hook and spear, and it is not difficult to see various causes for this. The capture by each of these gears is of less importance and of a more casual nature, than the capture in weels and seines.

The capture by spear moreover takes place to a large extent in the winter period from December to March. The statistics concerning this capture will thus to a great extent not be put down for the year for which we are considering the summer temperature. The yield of the hook fishery, which mainly takes place in the summer months, will be put down for the same year for which we are considering the summer temperature.

According to A. C. Johansen and E. Neergaard Möller (l. c.) the yield of eels captured by hooks or spears were distributed as follows during the various months in 1910 in the Kattegat, Belt Sea and Baltic.

January	4.5 %	July	22.0 %
February	4.5 -	August	11.5 -
March	5.0 -	September	5.1 -
April	4.7 -	October	2.8 -
May	11.5 -	November	2.8 -
June	21.1 -	December	4.5 -

In the statistics the catch by these two sorts of gears are put together.

C. Are the silver eels captured earlier after warm summers than after cold summers.

The yield of the eel fishery is only stated per year in the official Danish statistics, but from most localities monthly information is collected, and from Fiskeridirektør MORTENSEN we have received a series of monthly information concerning the capture of weel eels in autumn from the stretch Bisserup—Korsør by the Great Belt where a proportionately considerable weel fishery is carried on (see Fig. 1).

In order to investigate whether a seasonal displacement depending on the temperature in the summer months occurs, we have examined the connection between the percentage of the September catch out of the total catch of eels caught in weels in autumn (September, October and November) and the temperature anomaly for the months May—August for the stretch Bisserup—Korsør for the years 1900—1919 and also for the stretch Bisserup, Korsør, Omø, Agersø and Egholm for 1909—1919. (See Table 5).

We thus obtained the following correlation coefficient and mean errors for these:

		Bisserup	Korsør	Bisserup, Korsør, Omø, Agersø and Egholm
Correlation coefficient	r	0.52	0.42	0.61
	σ_r	0.16	0.19	0.19
	$\frac{r}{\sigma_r}$	3.2	2.2	3.2

Thus it will be seen, that the September catch forms, on an average, a greater part of the total autumn catch in warm summers than in cold summers, and that the majority of silver eels are thus captured a little earlier in the year after a warm than after a cold summer.

Table 5. Distribution in per Cents of catch of Eels taken in weels at the S. W. Coast of Sealand according to time of capture.

Place of capture	Bisserup		Korsør		Bisserup & Korsør			Omø		Agersø & Egholm		Bisserup, Korsør Omø, Agersø and Egholm	
Time of capture	Sept. %	Okt.-Nov. %	Sept. %	Okt.-Nov. %	Sept. %	Okt.-Nov. %		Sept. %	Okt.-Nov. %	Sept. %	Okt.-Nov. %	Sept. %	Okt.-Nov. %
Year							Year						
1900	46	54	25	75	42	58							
01	34	66	7	93	28	72							
02	27	73	—	—	—	—							
03	71	29	8	92	42	58							
04	20	80	11	89	16	84							
05	74	26	28	72	53	47							
06	38	62	23	77	28	72							
07	19	81	28	72	23	77							
08	46	54	29	71	39	61							
09	16	84	5	95	10	90	1909	17	83	15	85	11	89
10	74	26	46	54	63	37	10	27	73	33	67	55	45
11	37	63	39	61	38	62	11	19	81	19	81	31	69
12	38	62	19	81	26	74	12	0	100	40	60	30	70
13	55	45	19	81	34	66	13	33	67	42	58	36	64
14	51	49	36	64	43	57	14	16	84	14	86	35	65
15	55	45	15	85	34	66	15	11	89	30	70	31	69
16	39	61	13	87	26	74	16	67	33	38	62	32	68
17	52	48	50	50	51	49	17	0	100	20	80	45	55
18	44	56	62	38	54	46	18	0	100	57	43	50	50
19	40	60	32	68	37	63	19	0	100	20	80	32	68

D. Fluctuations in the Eel-catch caused by other factors than the temperature.

We have seen in the previous chapters that temperature highly influences the yield of the eel fishery, especially with regard to the weel-caught eels, and we have, on the basis of the material at hand, shown the numerical connection between the catch anomaly per cent and the temperature anomaly. Now the question arises whether other essential variations in the capture exist apart from those which are due to temperature, and whether these variations can in the present state of one's knowledge be referred to definite causes or not.

There can be little doubt that in certain areas the amount of rain influences the catch of silver eels, as they are prevented in dry summers from migrating through small rivers and brooks because these are dried up. In the small Bornholm brooks this phenomenon appears very distinctly, but as special statistics concerning the catch of silver eels are not available for these or for others of our brooks we cannot subject this phenomenon to any mathematical treatment. The delayed silver eels

Table 6. Catch of Eels in Ringkøbing Fiord compared with Temperature and Rainfall etc.

Year	Catch of eels tons	Catch anomaly	Temperature June—August		Anomaly of the temperature	Rainfall June—August mm		Anomaly of the rainfall	Catch anomaly found from the anomaly of the temperature	Difference between the catch anomaly observed and the catch anomaly found from the temperature
			Tarm	Herning		Tarm	Herning			
1895	20	—101	14.8	14.9	—0.3	289	305	97	— 6	— 95
96	64	— 57	15.9	15.6	0.6	136	139	—63	11	— 68
97	75	— 46	16.3	16.4	1.2	180	220	0	23	— 69
98	166	45	14.4	14.5	—0 7	265	240	52	—13	58
99	285	164	15.3	16 0	0.5	116	103	—91	10	154
1900	214	93	15.8	16.4	0.9	119	130	—76	17	76
1	93	— 28	16.1	16.4	1.1	170	273	21	21	— 49
2	100	— 21	13.4	13.8	—1.6	177	175	—24	—30	9
3	77	— 44	14.4	14.8	—0.6	220	186	3	—11	— 33
4	70	— 51	14.8	15.2	—0.2	119	144	—69	— 4	— 47
5	80	— 41	16.2	16.4	1.1	189	218	3	21	— 62
6	96	— 25	14.9	15.5	0.0	195	197	— 4	0	— 25
7	107	— 14	13.2	13.2	—2.0	239	265	52	—38	24
8	121	0	15.0	15 7	0.2	140	237	—12	4	— 4
9	120	— 1	13.5	14.1	—1.4	228	244	36	—27	26
10	328	207	16.0	16.8	1.2	227	296	61	23	184
11	285	164	15.9	16.6	1.1	126	161	—57	21	143
12	171	50	15.3	15.8	0.4	229	191	10	8	42
13	96	— 25	14.4	15.0	—0 5	97	135	—84	—10	— 15
14	65	— 56	16.5	17.1	1.6	214	184	— 1	30	— 86
15	48	— 73	14.2	14.6	—0.8	249	222	35	—15	— 58
16	108	— 13	14.1	14.2	—1.0	247	322	84	—19	6
17	74	— 47	16.6	16.8	1.5	252	235	43	28	— 75
18	104	— 17	14.2	14.5	—0.8	141	211	—24	—15	— 2
19	72	— 49	13.5	13.8	—1 5	195	200	— 3	—28	— 21
20	117	— 4	14.9	15.0	—0.2	232	194	13	— 4	0
Mean	121		15.0	15.3		192	209			

Catch correlated with the temperature gives $r = 0.261$ $\sigma_r = 0.183$ $\frac{r}{\sigma_r} = 1.43$.

The coefficient of regression for determination of the catch anomaly C by the anomaly of the temperature T is 19 ($C = 19\,T$).

migrate — partly at any rate — to the sea in the following spring — and in several of our rivulets, a. o. on Bornholm, well marked descending silver eels are thus captured in spring.

Among the fishermen in the neighbourhood of Ringkøbing Fiord it is a general opinion that the eel catch in the very Fiord also depends to an essential degree on the amount of rain in summer and autumn. The yield in the Fiord and the anomaly for the yield for the period 1895—1920 is stated in Table 6 in the second and third column.

With regard to this Fiord it is not possible to distinguish between the catch of silver eels and the catch of yellow eels, but in order to investigate to what degree the total catch of eel depends on the temperature as well as on the amount of rain we have given in Table 6 column 4 and 5 the average temperature for June to August for the two stations Herning and Tarm, and the rainfall at the same stations for June—August in column 7 and 8. The anomalies for temperature and rainfall for both sta-

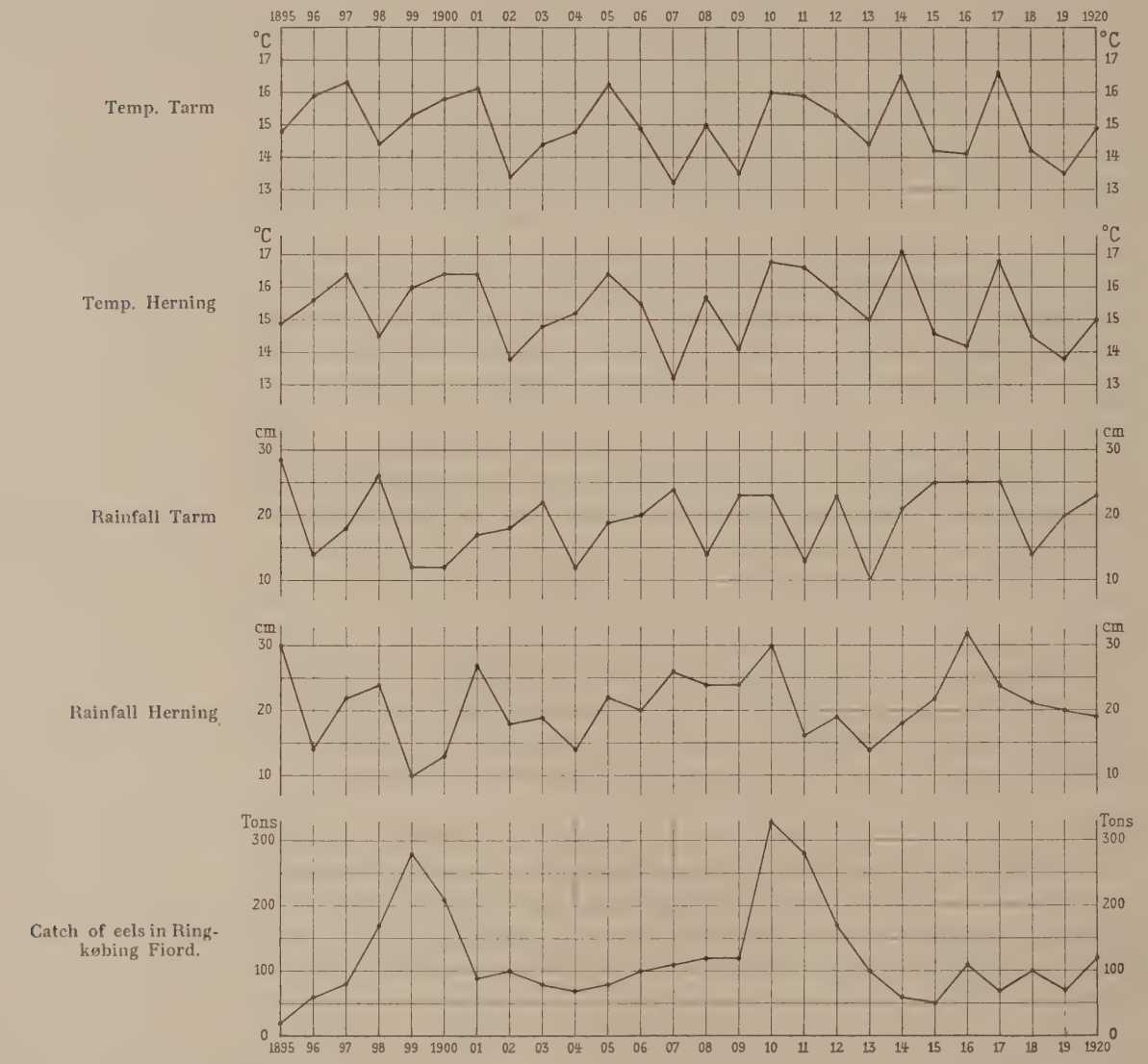
Temp. Tarm
Temp. Herning
Rainfall Tarm
Rainfall Herning
Catch of eels in Ringkøbing Fiord.
1895 96 97 98 99 1900 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 1920
°C
cm
Tons

Fig. 18. Catch of Eel (Anguilla vulgaris) in the Ringköbing Fiord compared with the Temperature and the Rainfall in Herning and Tarm (Jutland).

tions taken together will be found in column 6 and 9. A graphical representation of catch, temperature and rainfall is given in Fig. 18. By means of a calculation of the correlation coefficient for the dependence of the catch anomalies upon the temperature we obtain:

$$r = 0.261; \quad \sigma_r = 0.183; \quad \frac{r}{\sigma_r} = 1.43$$

which suggests that a connection probably exists between the total catch and the temperature[1]). As to the correlation between the rain fall and the catch anomaly we found:

$$r = -0.221; \quad \sigma_r = 0.186; \quad \frac{r}{\sigma_r} = -1.19.$$

This might seem to mean that the total catch should be greater in dry summers than in wet summers, which is contrary to the opinion expressed by the fishermen, but as a negative correlation exists (although a small one) between the temperature and the rainfall ($r = -0.189$; $\sigma_r = 0.189$, $\frac{r}{\sigma_r} = 1.00$) it will be seen that the negative correlation between the catch and the rainfall may appear on account of the negative correlation between the temperature and the rainfall, and consequently we can only state that the present material does not enable us to prove that the rainfall in June—August has any influence on the eel fishery. If the rainfall here really does influence the catch, it is very slight and far less than supposed by the fishermen. With regard to our other waters we have still less probability for tracing the influence of the rainfall on the eel-catch.

For further investigation as to whether any other causes can be traced in the variations of the catch we shall by means of the equations of regression eliminate the influence of the temperature and regard the remainder of the variations in the catch.

For the total capture of eels in the Limfiord, the Kattegat, the Sound and the Belt Sea we have found in Table 1 a correlation coefficient between the catch anomaly per cent and the temperature anomaly $r = 0.694$ and for the dependence of the capture upon the temperature we have the regression equation — catch anomaly per cent = 12.3 × the temperature anomaly — the temperature anomaly being reckoned for the time May—September (Celsius degrees). The difference between the catch anomaly per cent obtained and that calculated by the temperature anomaly amount to the following values for the different years:

1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916
—10	0	—13	—1	9	16	15	—2	5	3	—2	8	0	—7	—15	2	15	5	3	—11	—24

As stated above, we have for Ringkøbing Fiord found a correlation coefficient between the catch anomaly percentage and the temperature anomaly $r = 0.261$ and the regression equation will thus be as follows:

Catch anomaly (tons) = 19 × temperature anomaly (Celsius-degrees), and by application of this we arrive at the calculated catch anomalies put down in Table 6 column 10. The difference between the obtained and the calculated catch anomalies is stated in column 11 and is represented graphically on Fig. 19 together with the corresponding differences for the total catch in the Limfiord, the Kattegat, the Sound and the Belt Sea (the figures indicated above).

It will be seen that whilst we found marked maxima for the catch in the Limfiord, the Kattegat, the Sound and the Belt Sea in 1900—1902 and 1912, we find marked maxima for Ringkøbing Fiord in 1899 and 1910—11, thus about 2 years earlier. It might be presumed that the occurrence of these maxima could be ascribed to the same cause, and the suggestion presents itself that the cause might be due to the existence of great numbers of montées in certain years previously. That the maximum in the catch should occur ca. 2 years earlier in Ringkøbing Fiord than in the Limfiord, the Kattegat, Sound and Belt Sea might be explained by the supposition that the eels in Ringkøbing Fiord are on an average

[1]) Though the temperature's influence on the catch for Ringköbing Fiord appears to be slight and uncertain we may however attribute some importance to it on account of the good accordance between catch and temperature, which we have found for other waters.

two years younger at the time of capture than in the other areas, and this does not seem improbable, as they are, on an average, smaller.

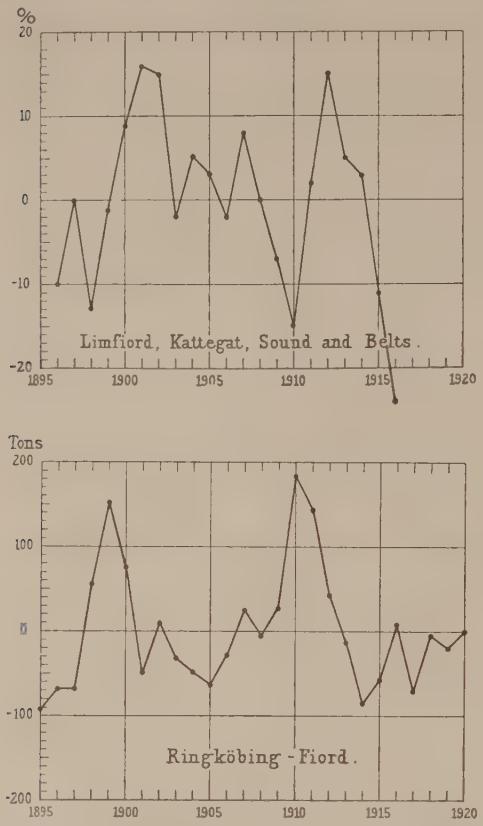

Fig. 19. Catch anomaly, influence of Temperature eliminated.

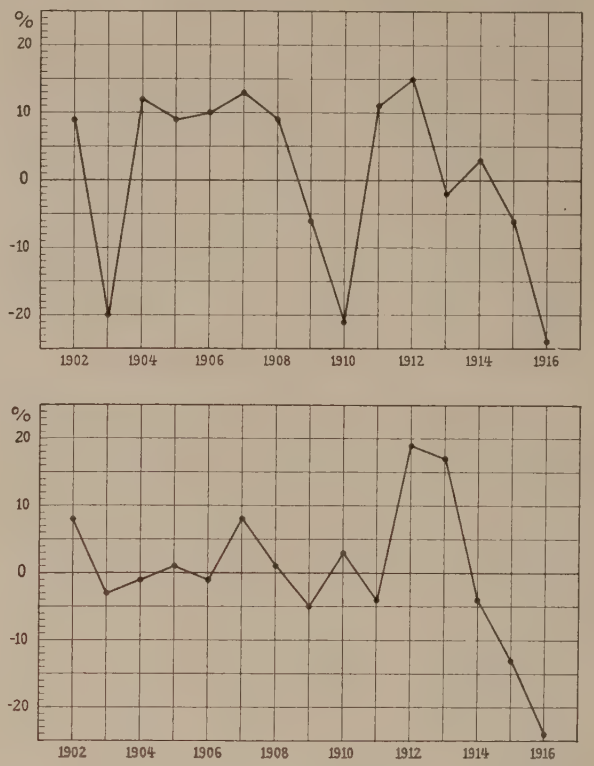

Fig. 20. Catch anomaly per cents, influence of Temperature eliminated. Upper figure: Eels caught in weels, the whole of Denmark. Lower figure: Eels caught in seines, the whole of Denmark.

This hypothesis is however weakened by the fact that the maxima noticed for the eels caught in seines for the areas 1—6, when the calculated influence of the temperature has been subtracted, does not occur earlier than for the eels caught in weels The curves represented on Fig. 20 show that these maxima occur at the same time for the eels caught in weels and for the eels caught in seines which are younger on an average. One of several possibilities is, that the maxima in question may be due mainly to the circumstance that the fishery has been carried on with a proportionately high intensity in the periods concerned That this probably has been the case in Ringkøbing Fiord in the years 1898—1900, is mentioned elsewhere[1]).

E. The practical importance of these investigations.

Among the results obtained from the investigations carried out there is at least one which may be of practical importance, namely, that the yield of eels caught in weels may be expected to be several per cents higher for each degree by which the mean temperature for August is higher than normal. If

[1]) A. C. Johansen: Om Forandringer i Ringkøbing Fjords Fauna p. 124. Mindeskrift for Japetus Steenstrup. København 1914, Bd. II.

it appears that the temperature in August is proportionately high, the fishermen ought especially to try to utilise the chances for a great catch by taking part in the weel fishery and by employing a proportionately large number of gears. Generally the fishermen will, to some degree, be able to judge how far the August temperature in a certain place is proportionately high, but they ought in this connection to be able to derive help from an organised service for communicating anomalies of temperature. As a high July temperature also, to some degree, appears to increase the number of silver eels, and as a certain agreement generally exists between the July temperature and the August temperature, weekly statements from the beginning of July ought to be published concerning the temperature in proportion to the normal temperature, and these statements ought to continue till the end of August. Without much trouble such communications might be made in the weekly fishery-periodicals after collaboration with the Meteorological Institutes.

DANSK RESUMÉ

J. P. JACOBSEN og A. C. JOHANSEN:

OM AARSAGERNE TIL FLUKTUATIONERNE I UDBYTTET AF VISSE AF VORE FISKERIER.

II. Aalefiskeriet.

A. Indledning.

Aalefiskeriet er et af de vigtigste Fiskerier i Danmark. Det har navnlig Betydning ved Kysterne af vore indre Farvande, og det foregaar ogsaa i saa at sige alle vore Aaer og Søer. Det er et relativt stabilt Fiskeri, idet det i en længere Periode er drevet paa ret ensartet Maade i forskellige Aar. Ganske vist er der i de sidste 30 Aar foregaaet en betydelig Udvikling af Fiskeriet, men denne Udvikling har været ret jævn. For Kystfiskeriets Vedkommende bestaar Udviklingen i Hovedsagen i følgende Forhold:

1. Antallet af Ruser og Drivvaad er blevet stærkt forøget.
2. Ruserne anbringes delvis paa dybere Vand og længere fra Kysten end tidligere.
3. Større Redskaber er bragt i Anvendelse, dels store Ruser, dels Bundgarn.

Til Trods for Stabiliteten med Hensyn til Fiskemaaden og den jævne Udvikling i den Intensitet, hvormed Fiskeriet drives, er der anselige aarlige Vekslinger i Udbyttet. Aarsagerne hertil maa i det hele siges at være ukendte eller i alt Fald utilstrækkelig belyste. De formentlige Aarsager til Fluktuationerne, som Fiskerbefolkningen har Opmærksomheden henvendt paa, har i Reglen en lokal Karakter, f. Eks. de mere eller mindre gunstige Strøm- og Vindforhold under »Mørkerne« i Efteraarstiden, hvor Hovedfangsten af Blankaalen finder Sted. — Undertiden hører man den Opfattelse udtalt, at Aalefiskeriet giver det største Udbytte i varme Somre, og paa visse Steder, bl. a. paa Bornholm og i det vestlige Jylland, kan man høre den Opfattelse fremsat med stor Styrke, at Fiskeriet efter Blankaal giver det mindste Udbytte i tørre Somre.

Den Tanke, at Aalefiskeriet giver et større Udbytte i varme end i kolde Somre, er flere Gange fremsat i den danske Litteratur. I en Afhandling: »Om Udbyttet af Limfjordens Fiskerier i de senere Aar«[1]) etc. kommer C. G. Joh. Petersen ind paa en Sammenligning mellem Fangsten af Rødspætter og Fangsten af Aal i Limfjorden, og han kommer herved til det Resultat, at i de Aar, hvor Fangstudbyttet af den ene af disse Arter er lille, er det stort af den anden Art. Som Forklaring paa dette Fænomen fremsætter Dr. Petersen følgende Bemærkninger:

»Disse to Fiskerier supplere altsaa hinanden, hvilket delvis maa antages at ligge i, at vestlige Vinde om Foraaret og Sommeren med vestlig Strøm og lav Temperatur ere fordelagtige for Rødspættens Indvandring og ikke skadelig for dens Vækst, medens Aalen fordrer varme Somre for at vokse stærkt; men tillige forstærkes denne Virkning vistnok ogsaa derved, at Fiskerne i de gode Aaleaar holde

[1]) Beretning XVIII fra den danske biologiske Station. København 1909.

sig mest til Aalefiskeri, og derved lægge mindre Vind paa Rødspættefiskeriet, medens det omvendte er Tilfældet i de gode Rødspætteaar.«

I sin Beskrivelse af Danmarks Fiske fremsætter C. V. Otterstrøm bl. a. følgende Bemærkninger om Aalefangsten: »I varme Somre vokser Aalen bedst hos os, og Blankaalsfiskeriet synes ogsaa at blive størst efter de varme Somre«[1]).

I Dansk Fiskeritidende No. 47 for 23. November 1915 hævder Dueholm, at i de Aar, hvor man har en varm Forsommer, bliver Udbyttet af Blankaalfiskeriet det følgende Efteraar relativt stort. Dueholm søger at vise Rigtigheden af sin Opfattelse ved at sammenligne Kurven over Luftens Middeltemperatur i Maj, Juni, Juli i Perioden 1905—14 med Kurven over det aarlige Fangstudbytte af Blankaal i den nævnte Periode.

Dueholms Kurver viser paa væsentlige Punkter en tydelig Overensstemmelse mellem Temperaturen og Fangstudbyttet, men paa andre Punkter stemmer de øjensynlig ikke overens. Medens Sommertemperaturen falder fra 1905 til 1906 stiger Udbyttet betydeligt, og medens vi iagttager et gradvis Fald i Sommertemperaturen for Aarene 1910—1913, ser vi en stadig Stigning i Udbyttet indenfor samme Periode. Om disse Uoverensstemmelser skriver Dueholm følgende:

»De mindre Uoverensstemmelser, der ved nøjere Eftersyn viser sig at være, lader sig sikkert delvis — bortset fra Tilfældighederne etc. — forklare ved Hjælp af det rette Kendskab til »Redskabskoefficienten« samt til Temperatur, Vindretning, Vindstyrke, Vejrliget og Maanens Stilling i Fangstmaanederne September og Oktober.«

De her omtalte Betragtninger af Petersen, Otterstrøm og Dueholm vil vi i nærværende Afhandling søge at belyse nærmere. Vi vil foretage en Undersøgelse af Forbindelsen mellem Temperaturen og Fangsten af Aal i de danske Farvande og vil herved ogsaa komme ind paa Spørgsmaalet, om Temperaturen har Indflydelse baade paa Fangsten af Blankaal og paa Fangsten af gule Aal.

B. Om Temperaturens Indflydelse paa Vekslingerne i Fangsten af Blankaal og gule Aal.

Den Oversigt over Fangstudbyttet, vi giver i Tabellerne 1 og 2, er uddraget fra den officielle danske Fiskeri-Beretning. Vi skelner mellem følgende Omraader[2]): (Se Fig. 1).

1. Limfjorden.
2. Jyllands Østkyst fra Skagen til Hasenøre.
3. Isefjorden.
4. Belthavet.
5. Sundet.
6. Bornholm.

Statistiken over Fangsten af Aal kan føres tilbage til 1896 for Limfjordens Vedkommende[3]) og til 1885 for de andre nævnte Omraader. Vi fører her kun Undersøgelsen frem til Aaret 1916, idet der her i Landet i Aarene 1917—1919 som Følge af Krigsforholdene herskede en stærk Mangel paa Redskaber til Fangst af Aal (og andre Fiskearter).

Til Sammenligning med Fangststatistiken for de nævnte Omraader har vi benyttet de Angivelser af Overfladetemperaturen[4]), som findes offentliggjorte i »Nautisk Meteorologisk Aarbog«, idet der er

[1]) C. V. Otterstrøm: Danmarks Fauna 15. Fisk II Blødfinnefisk. København 1914. p. 332.

[2]) Aalefangsten i Ringkøbing Fjord omtales i et følgende Kapitel (Kap. D).

[3]) Statistiken over Værdien af Fangsten kan for Limfjorden føres tilbage til 1890.

[4]) Naar Dueholm har foretaget en Sammenligning mellem Lufttemperaturen og Fangsten af Blankaal, er der intet væsentligt at indvende herimod. Der er i Sommertiden en betydelig Overensstemmelse mellem Lufttemperaturen og Temperaturen i de grundere Dele af saavel vore ferske Vande som vore salte Fjord- og Kystvande, hvor Aalen fortrinsvis opholder sig. Da vi har talrige og let tilgængelige Oplysninger om Temperaturen af Overfladevandet ved vore Kyster, og da der paa visse Steder og til visse Tider faktisk kan være ret betydelige Uoverensstemmelser mellem Lufttemperaturen og Overfladevandets Temperatur i Forsommeren, har vi dog fundet det rigtigst at benytte Overfladetemperaturen.

beregnet Middeltal for Temperaturen, saaledes at disse Middeltal saa godt som muligt kan siges at repræsentere Temperaturforholdene indenfor det paagældende Omraade. Valget af de Stationer som er benyttet til Middeltalsdannelsen, vil fremgaa af Tabel 3, Side 8—9.

Den Opgave, vi først stiller os, er at undersøge Forbindelsen mellem Sommertemperaturen og den samlede Fangst af Aal i de danske Farvande indenfor Skagen samt Limfjorden i Aarene 1896—1916 (se Tabel 1). Vi beregner da her Korrelationen mellem den procentiske Anomali af Fangsten og Temperaturanomalien, idet vi betragter Temperaturen af Overfladevandet i Maj—September ved de paa Tabel 3 opførte Stationer[1]). Vi finder da her følgende Værdier:

$$r = 0.694; \quad \sigma_r = 0.113; \quad \frac{r}{\sigma_r} = 6.1.$$

Det ses saaledes, at der er en tydelig og utvivlsom Forbindelse mellem Temperaturen og Fangstudbyttet, og at Udbyttet bliver størst, naar Sommertemperaturen er højest.

Af den ovenfor anførte Beregning kan man ikke slutte, om det store Udbytte i varme Somre skyldes en Forøgelse i Massen af Blankaal eller en Forøgelse i Massen af gule Aal eller en Forøgelse i begge Slags Aal. Men den danske Fiskeristatistik er heldigvis specialiseret saaledes, at dette Forhold kan undersøges nærmere. I Perioden 1885—1901 skelnes der i Statistiken mellem

1. Aal fanget i Ruser og med Krog og Stangredskaber.
2. — — i Vaad.

I Perioden fra og med 1902 skelnes imellem

1. Aal fanget i Ruser (og Bundgarn).
2. — — i Vaad.
3. — — paa Krog og med Stangredskaber.

Som det er vel bekendt, er det i Reglen aldeles overvejende blanke Aal, der fanges i Ruser, medens det overvejende er gule Aal, der fanges i Vaad, paa Krog og med Stangredskaber. For Perioden efter 1902 foreligger der da et godt Materiale til Adskillelse mellem blanke Aal og gule Aal. Vi vil da undersøge Forbindelsen mellem Sommertemperaturen og Totalfangsten af Aal fanget med hver enkelt Gruppe af de nævnte Redskaber i 1902—1916. (Se Tabel 2 og Tabel 3). Ved en Korrelationsberegning kommer vi da her til følgende Resultat:

1. Aal fanget i Ruser, 1902—1916.
   Den procentiske Anomali for Fangst korreleret med Temperaturanomalien for Maj—September:

$$r = 0.790, \ \sigma_r = 0.097, \ \frac{r}{\sigma_r} = 8.1. \text{ (Se Fig. 15).}$$

2. Aal fanget i Vaad, 1902—1916.
   Den procentiske Anomali for Fangst korreleret med Temperaturanomalien for Maj—August:

$$r = 0.561, \ \sigma_r = 0.177, \ \frac{r}{\sigma_r} = 3.2.$$

3. Aal fanget paa Krog og stanget, 1902—16.
   Den procentiske Anomali for Fangst korreleret med Temperaturanomalien for Maj-August:

$$r = 0{,}081, \ \sigma_r = 0.256, \ \frac{r}{\sigma_r} = 0.3.$$

[1]) Ved den procentiske Fangstanomali forstaar vi det Antal Procent, som Forskellen mellem det virkelige Fangstudbytte og Normalfangsten udgør af Normalfangsten.

Om Fremgangsmaaden ved Korrelationsberegningen, se J. P. Jacobsen & A. C. Johansen: On the Causes of the Fluctuations in the yield of some of our Fisheries. I. The Salmon and Sea Trout Fisheries p. 7—12.

Ved denne Analyse ses det, at der er en Sammenhæng mellem Temperatur og Fangst baade af Aal fanget i Ruser og Aal fanget i Vaad, medens der ikke kan paavises nogen Forbindelse mellem Sommertemperaturen og Fangsten af Aal paa Krog og stanget Aal.

Den fundne Korrelation mellem Temperaturen og Fangsten af Blankaal (Ruseaal), maa uden Tvivl forklares ved, at Temperaturen — som for Laksens og Ørredens Vedkommende — virker fremskyndende paa Modningen. Mange af de Aal, der i varme Somre bliver blanke, vilde i mindre varme Somre ikke have anlagt denne Dragt. Det store Udbytte af Blankaal i varme Somre skyldes sikkert den Omstændighed, at der fremkommer flere Blankaal end normalt. Rimeligvis er Blankaalen i varme Somre ikke større end normalt, maaske snarere — som Opgangslaksen af yngste Gruppe — gennemsnitlig mindre end normalt. Et tilstrækkeligt Materiale til nærmere Belysning af dette Spørgsmaal har vi dog ikke haft.

Fangsten af Blankaal foregaar overvejende i de maanemørke Nætter fra Midten af September til Midten af November. Det Spørgsmaal ligger nu nær, paa hvilken Tid af Sommeren en relativt høj Temperatur indvirker stærkest paa Fangstudbyttet. For at opnaa en foreløbig Orientering om dette Spørgsmaal vil vi korrelere Temperaturanomalierne for hver enkelt Maaned med den procentiske Fangstanomali. Vi faar herved følgende Resultat, idet vi betragter Totalfangsten af Ruseaal i de forannævnte danske Farvande i Perioden 1902—1916:

Temp. anomal. korr. med Fangstanomali for Ruseaal, 1902—1916.

Maj	$r = 0.583$;	$\sigma_r = 0.170$;	$\frac{r}{\sigma_r} = 3.4$,
Juni	$r = 0.636$;	$\sigma_r = 0.154$;	$\frac{r}{\sigma_r} = 4.1$,
Juli	$r = 0\,620$;	$\sigma_r = 0.159$;	$\frac{r}{\sigma_r} = 3.9$,
August	$r = 0.801$;	$\sigma_r = 0.092$;	$\frac{r}{\sigma_r} = 8.7$,
September	$r = 0.525$;	$\sigma_r = 0.187$;	$\frac{r}{\sigma_r} = 2.8$.

Det ses heraf, at Korrelationsfaktoren for August Maaned har langt større Værdi end for de øvrige Maaneder, men at den dog ogsaa for disse Maaneder er positiv og har betydelige Værdier. (Se Fig. 15—16).

Dette Forhold, at der viser sig en Korrelation mellem den procentiske Fangstanomali og Temperaturanomalien i Maj, Juni, Juli og i September, kunde imidlertid tænkes at fremkomme ved, at der findes en ikke ringe Korrelation mellem Augusttemperaturen og Temperaturen i de øvrige Sommermaaneder, saaledes, at man efter det foreliggende Talmateriale kun er berettiget til at slutte, at der findes en Sammenhæng mellem Augusttemperaturen og Fangsten.

For saa vidt muligt at faa afgjort, hvilken Indflydelse Temperaturen i de enkelte Maaneder har paa Fangsten, har vi undersøgt denne Afhængighed paa følgende Maade. Vi gaar ud fra, at Fangstanomalien F kan udtrykkes ved Temperaturanomalierne

t_{Maj}, t_{Juni}, t_{Juli}, t_{August} og $t_{September}$ henholdsvis for Maanederne Maj—September ved

$$F = k_{Maj} \times t_{Maj}, + k_{Juni} \times t_{Juni}, + k_{Juli} \times t_{Juli}, + k_{Aug.} \times t_{Aug.}, + k_{Septbr.} \times t_{Septbr.},$$

idet k_{Maj}, k_{Juni}, k_{Juli}, $k_{Aug.}$ og $k_{Septbr.}$

er Konstanter, med hvilke de paagældende Temperaturanomalier skal multipliceres for at give den forefundne Fangstanomali.

Ved de følgende Beregninger er Fangsten og Fangstanomalien regnet med 1000 kg som Enhed og den procentiske Fangstanomali som det Antal Procent, Anomalien udgør af Normalfangsten, der er fundet ved grafisk Udjævning (se Fig. 2—14). Temperaturanomalien er regnet i Tiendedelsgrader som Afvigelse fra Middeltemperaturen.

Betydningen af Konstanterne k_{Maj}, k_{Juni} o. s. v. kan da formuleres som det Antal Procent med hvilke Normalfangsten vil stige, naar Temperaturen i den Maaned, for hvilken Konstanten gælder, er $^1/_{10}$ Grad højere end normalt.

Beregningen er gennemført for Observationsmaterialet 1902—1916 for det samlede Omraade efter de mindste Kvadraters Metode og har givet følgende Resultat:

Konstanter					Middelfejl				
k_{Maj}	k_{Juni}	k_{Juli}	$k_{Aug.}$	$k_{Septbr.}$	k_{Maj}	k_{Juni}	k_{Juli}	$k_{Aug.}$	$k_{Septbr.}$
—0.02	0.53	0.13	1.40	—0.65	1.04	0.49	0.45	0.66	0.80

Det fremgaar af disse Tal, at man med betydelig Sikkerhed tør gaa ud fra, at det er Augusttemperaturen — og ikke som af Dueholm antaget Temperaturen i Forsommeren omkring Maj—Juli — der har den dominerende Indflydelse paa Fangsten af Blankaal. Om Temperaturen i Maanederne Maj, Juni, Juli og September overhovedet har nogen Indflydelse paa Fangsten af Blankaal, kan ikke siges med Sikkerhed paa Grundlag af det foreliggende Materiale. De fundne Konstanter for disse Maaneder er kun af omtrent samme Størrelse eller endogsaa mindre end deres Middelfejl. Sandsynligheden er imidlertid størst for, at en relativ høj Temperatur i Juni og Juli i nogen Grad bidrager til at øge Fangsten. Den fundne Værdi for $k_{Aug.} = 1.40$ betyder, at man, naar Middeltemperaturen for August er 1° C. højere end normalt, maa vente, at Fangsten af Ruseaal i Efteraarsmaanederne bliver ca. 14 % højere end normalt ($\pm$ 6.6 %).

I det foregaaende har vi undersøgt Korrelationen mellem Temperaturanomalierne og Fangstanomalierne for Ruseaal for alle de danske Farvande indenfor Skagen plus Limfjorden under ét. Vi vil nu gaa over til at betragte Korrelationen mellem Temperaturanomalierne og Fangstanomalierne i hver af de foran nævnte Omraader for sig, idet vi dog her maa se bort fra Bornholm, hvor det forhaandenværende statistiske Materiale for Fangsten er for lille og tilfældigt til at afgive Basis for en Korrelationsberegning. Vi kommer da herved til følgende Resultat:

Temperaturanomalien for Maj—September korreleret med Anomalierne for Fangst af Ruseaal i Perioden 1902—1916:

Limfjorden	$r = 0.418$;	$\sigma_r = 0.213$;	$\frac{r}{\sigma_r} = 2.0.$
Jyllands Østkyst	$r = 0.352$;	$\sigma_r = 0.226$;	$\frac{r}{\sigma_r} = 1.6.$
Isefjorden	$r = 0.238$;	$\sigma_r = 0.244$;	$\frac{r}{\sigma_r} = 1.0.$
Belthavet	$r = 0.738$;	$\sigma_r = 0.118$;	$\frac{r}{\sigma_r} = 6.3.$
Sundet	$r = 0.604$;	$\sigma_r = 0.164$;	$\frac{r}{\sigma_r} = 3.7.$

Den forholdsvis ringe Værdi af Korrelationskoefficienten for Jyllands Østkyst peger hen paa, at der langs denne Kyst ikke finder noget stort Træk af Blankaal Sted saaledes som i Bælterne og Sundet. Hovedmassen af Blankaalen fra de indre danske og baltiske Farvande følger aabenbart det aabne Kattegat og Skagerak paa Vejen ud imod Nordsøen.

At Korrelationskoefficienten er lille for Isefjordens Vedkommende, maa ses paa Baggrund af den ringe Fangst. Aarsager af tilfældig Art kan her komme til at influere stærkt paa Fangstens Størrelse.

Den ret ringe Værdi af Korrelationskoefficienten for Limfjordens Vedkommende (i Forhold til Sundet og Belthavet) forklares paa følgende Maade: Blandt de Aal, der fanges i Ruser i Limfjorden, er en forholdsvis stor Procentdel gule Aal. Fiskerikontrollør Andersen anslaar Blankaalen til kun at udgøre ca. 40 % i Vægt af alle de i Limfjorden fangede Ruseaal. Rusefiskeriet i Limfjorden efter gule Aal be-

gynder allerede i Marts, efter blanke Aal først i September. Noget stort Træk af Blankaal fra andre Farvande foregaar der aabenbart ikke gennem Limfjorden.

I Perioden 1885—1901 er Ruseaalen ikke i Statistiken holdt adskilt fra Aal fanget med Krog og Stangredskaber. Til Trods herfor faar Korrelationskoefficienten dog en betydelig Størrelse, hvis vi korrelerer Temperaturanomalien for Sommermaanederne med Fangstanomalien. Dette er ogsaa kun naturligt, da Fangsten i Ruser udgør en væsentlig Del af denne Fangst. En Beregning for Belthavet, der er vort vigtigste Farvand for Aalefiskeriet, giver følgende Resultat:

Temperaturanomalien for Maj—September korreleret med Anomalien for Fangsten af Aal med Ruser, Krog og Stangredskaber i Perioden 1885—1901:

$$r = 0.712; \quad \sigma_r = 0.120; \quad \frac{r}{\sigma_r} = 5.9. \quad \text{(Se Fig. 17).}$$

Fangsten af Aal med Vaad foregaar overvejende i Tiden fra Maj til August.

Som foran anført (S. 26) finder man ved Beregningen af Korrelationen mellem Temperaturanomalierne for Maj—August og Fangstanomalierne for Aal fanget i Vaad en Værdi for r af 0.561, naar man betragter alle de danske Farvande indenfor Skagen samt Limfjorden under ét. Betragter man de vigtigste Omraader særskilt, faas følgende Værdier:

Temperaturanomalier for Maj—August korreleret med Anomalier for Fangst af Aal fanget i Vaad i Perioden 1902—1916

$$\text{Limfjorden} \quad r = 0.325; \quad \sigma_r = 0.231; \quad \frac{r}{\sigma_r} = 1.4,$$

$$\text{Isefjorden} \quad r = 0.295; \quad \sigma_r = 0.236; \quad \frac{r}{\sigma_r} = 1.3,$$

$$\text{Belthavet} \quad r = 0.355; \quad \sigma_r = 0.226; \quad \frac{r}{\sigma_r} = 1.6.$$

Det vil ses, at de fundne Værdier for Korrelationskoefficienten her gennemgaaende er meget mindre, men mere ensartede end for Blankaalens Vedkommende.

Paa lignende Maade som for Ruseaalen har vi dernæst undersøgt, om der kan paavises en Sammenhæng mellem Fangstudbyttet af Vaadaalen og Temperaturens Afvigelse fra den normale Værdi i Maanederne Maj, Juni, Juli og August. Undersøgelsen er indskrænket til disse fire Maaneder, da Fangsten af Aal med Vaad hovedsagelig kun finder Sted i Sommermaanederne.

Ligesom ved Behandlingen af Problemet for Blankaalen betegner vi den aarlige procentiske Fangstanomali gældende for hele Danmark ved F, og idet t_{Maj}, t_{Juni}, t_{Juli} og t_{August} betegner Temperaturanomalierne udtrykt i Tiendedelsgrader i de ved Indices angivne Maaneder sætter vi

$$F = k_{Maj} \cdot t_{Maj} + k_{Juni} \cdot t_{Juni} + k_{Juli} \cdot t_{Juli} + k_{August} \cdot t_{August}.$$

idet k_{Maj}, k_{Juni}, k_{Juli} og k_{August} betyder de Konstanter, hvormed Temperaturanomalier i de paagældende Maaneder i et bestemt Aar skal multipliceres for saa nær som muligt at give den forefundne procentiske Fangstanomali. En Beregning af Konstanterne paa Grundlag af det i Tabel 2 og 3 anførte Materiale ved de mindste Kvadraters Metode gav til Resultat:

Konstanter				Middelfejl for Konstanterne			
k_{Maj},	k_{Juni},	k_{Juli},	k_{August}	k_{maj},	k_{Juni},	k_{Juli},	k_{August}
0.317	0.443	0.566	— 0.319.	0.63	0.37	0.35	0.44.

Det fremgaar heraf, at Konstanterne gennemgaaende er smaa i Forhold til deres Middelfejl. Dog er Konstanten for Juli 1.6 Gange dens Middelfejl. Endvidere maa det bemærkes, at Fortegnene er ens for de tre første Konstanter. Man maa derfor være berettiget til at slutte, at der er stor Sandsynlighed for, at en høj Temperatur i Forsommeren og særlig i Juli giver Aarsag til et

relativt stort Fangstudbytte af gule Aal. Betydningen af Konstanten k_{Juli}, der maa anses for den sikrest bestemte, kan udtrykkes saaledes, at naar Julitemperaturen er 1° højere end normalt, maa man vente, at Fangsten i Kilogram af gule Aal det paagældende Aar vil være 6 % højere end normalt ($\pm$ 3.5 %).

Det relativt høje Udbytte af Fiskeriet efter gule Aal i varme Somre, maa rimeligvis, i alt Fald delvis forklares ved, at den gule Aal ved en høj Sommertemperatur har en forholdsvis hurtig Vækst. De Svingninger i Udbyttet, der fremkaldes af Temperaturen, er dog her ikke nær saa store som for Blankaalens Vedkommende, og den Mulighed er ikke udelukket, at Temperaturens Virkning paa Svingningerne i Fangsten af gule Aal som af PETERSEN antaget kan forstærkes ved, at Fiskerne i varme Somre driver Aalefiskeriet mere intensivt end i kolde Somre.

Som foran anført kan der ikke iagttages nogen Forbindelse mellem Sommertemperaturen og Fangsten af Aal, der er taget paa Krog og med Stangredskaber, og det er ikke vanskeligt at faa Øje paa forskellige Aarsager hertil. Fangsten med hvert af disse Redskaber har mindre Betydning og er mere tilfældig end Fangsten med Ruser og Vaad. Desuden foregaar Fangsten med Stangredskaber i væsentlig Grad i Vintertiden fra December til Marts, saaledes at Statistiken over denne Fangst for største Delen ikke opføres for det Aar, hvori man betragter Sommertemperaturen. Dette er derimod Tilfældet med Krogfiskeriet, der overvejende foregaar i Sommermaanederne.

C. Fanges Blankaalen tidligere paa Aaret efter varme Somre end efter kolde Somre.

Aalefangsten angives kun aarevis i den officielle danske Statistik, men fra de fleste Lokaliteter indsamles maanedlige Oplysninger, og fra Fiskeridirektør MORTENSEN har vi modtaget en Række maanedlige Opgivelser om Fangsten af Ruseaal i Efteraarstiden fra Strækningen Bisserup—Korsør ved Store Belt, hvor der drives et forholdsvis stort Fiskeri med Ruser.

For at undersøge om der findes en Sæsonforskydning, som afhænger af Temperaturen i Sommermaanederne, undersøgtes Sammenhængen mellem den Brøkdel som Septemberfangsten udgjorde af den samlede Fangst af Aal fanget i Ruser i September, Oktober og November og Temperaturanomalien for Maanederne Maj—August for Pladserne Bisserup og Korsør for Aarene 1900—1919 samt for Omraadet Bisserup, Korsør, Omø, Agersø og Egholm for 1908—1919. (Tabel 5, Side 18).

Der fandtes derved følgende Korrelationskoefficienter og Middelfejl for disse.

	Bisserup	Korsør	Bisserup, Korsør, Omø, Agersø og Egholm
Korrelationskoefficient r . .	0.52	0.42	0.61
σ_r . .	0.16	0.19	0.19
$\frac{r}{\sigma_r}$ . .	3.2	2.2	3.2

Det ses saaledes, at Septemberfangsten gennemgaaende udgør en større Del af den samlede Efteraarsfangst i varme Somre end i kolde Somre, og at Hovedmassen af Blankaalen altsaa fanges lidt tidligere paa Aaret efter en varm Sommer end efter en kold Sommer.

D. Fluktuationer i Aalefangsten frembragt af andre Faktorer end Temperaturen.

Vi har i de foregaaende Kapitler set, at Temperaturen øver en stærk Indflydelse paa Størrelsen af Fangsten af Aal, særlig Ruseaal, og der er paa Grundlag af det foreliggende Materiale vist den talmæssige Sammenhæng mellem den procentiske Fangstanomali og Temperaturanomalien. Der rejser sig nu det Spørgsmaal, om der findes andre væsentlige Variationer i Fangsten end de, som skyldes Temperaturen, og om disse Variationer for Tiden kan henføres til bestemte Aarsager eller ikke.

I visse Omraader er det ganske givet, at Regnmængden har Indflydelse paa Størrelsen af Fangsten af Blankaal, idet denne i tørre Somre hindres i at komme frem gennem smaa Aaer og Bække paa Grund af, at disse udtørres. I de smaa bornholmske Aaer fremtræder dette Fænomen med stor Tydelighed, men nogen speciel Statistik over Fangsten af Blankaal haves ikke for disse eller andre af vore Aaer, saa Fænomenet kan ikke her gøres til Genstand for nogen talmæssig Behandling. De forsinkede Blankaal udvandrer allerede til Havet i det følgende Foraar — i alt Fald delvis — og i flere af vore Aaer, bl. a. de bornholmske, fanges der saaledes udprægede Blankaal for Nedtræk allerede i Foraarstiden.

Blandt Fiskere i Egnen omkring Ringkøbing Fjord er det en almindelig Antagelse, at Udbyttet af Aalefiskeriet ogsaa i selve Fjorden i væsentlig Grad er afhængig af Regnmængden. Opgivelser af Fangstudbyttet i Fjorden og Anomalien for Fangstudbyttet for Aarrækken 1895—1920 findes opgivet i Tabel 6 (Side 19) i 2den og 3dje Kolonne. Nu kan for denne Fjords Vedkommende Fangsten af Blankaal og Fangsten af gule Aal ikke holdes adskilt, men for at undersøge i hvilken Grad Totalfangsten af Aal kan antages at være afhængig saavel af Temperatur som Regnmængde er i Tabel 6, Kolonne 4 og 5 anført Middeltemperaturen for Juni til August for de to Stationer Herning og Tarm og i Kolonne 7 og 8 Nedbøren paa de samme Stationer ligeledes for Juni—August. Anomalierne for Temperatur og for Regnmængde for begge Stationer under eet er opført i Kolonne 6 og 9. En grafisk Fremstilling af Fangst, Temperatur og Regnmængde er anført i Fig. 18. En Beregning af Korrelationskoefficienten for Fangstanomaliens Afhængighed af Temperaturen giver:

$$r = 0.261; \quad \sigma_r = 0.183; \quad \frac{r}{\sigma_r} = 1.43$$

som tyder paa, at der findes en Sammenhæng mellem Totalfangsten og Temperaturen, om den end er usikker. For Korrelationskoefficienten for Fangstanomaliens Afhængighed af Regnmængden fandtes:

$$r = -0.221; \quad \sigma_r = 0.186: \quad \frac{r}{\sigma_r} = -1.19.$$

Dette kunde tyde paa, at Totalfangsten skulde være rigeligere i tørre Somre og mindst i Somre med stor Regnmængde; altsaa modsat den af Fiskerne udtalte Anskuelse, men da der findes en, om end kun ringe, negativ Korrelation mellem Temperatur og Regnmænde $\left(r = -0.189; \quad \sigma_r = 0.189; \quad \frac{r}{\sigma_r} = 1.00\right)$ ses det, at den negative Korrelation mellem Fangst og Regnmængde kan fremkomme ved den negative Korrelation mellem Temperatur og Regnmængde, saa at man faar som Resultat, at Regnmængden i Juni—August i det foreliggende Materiale ikke kan paavises at have nogen Indflydelse paa Aalefangsten. Øver Regnmængden her virkelig en Indflydelse paa Størrelsen af Fangsten, er den saaledes kun ringe, og langt ringere end af Fiskerne antaget. For vore andre Farvande er der endnu mindre Udsigt til, at Regnmængdens Indflydelse paa Størrelsen af Aalefangsten skulde kunne paavises.

Fradrages Temperaturens beregnede Virkninger fra det iagttagne Udbytte, viser det sig, at der bliver visse udprægede Maksima og Minima tilbage (Fig. 19, Side 22). For Limfjorden, Kattegat, Sundet og Belterne iagttages saaledes udprægede Maksima i Aarene 1901—1902 og 1912 og for Ringkøbing Fjord i 1899 og 1910—11. Det kunde formodes, at Fremkomsten af disse Maksima kunde tilskrives samme Aarsag, og den Tanke ligger nær, at Aarsagen kunde være en rigelig tilstedeværende Yngelmængde visse Aar i Forvejen. At Maksimum i Fangsten indtræder ca. 2 Aar tidligere i Ringkøbing Fjord end i Limfjorden, Kattegat, Sundet og Bælterne, skulde da ligge i, at Aalene i Ringkøbing Fjord ved Fangsten gennemsnitlig skulde være et Aar yngre end i de forannævnte Omraader, hvad der ikke synes urimeligt at antage, da de gennemsnitlig er mindre.

Denne Betragtning svækkes dog ved den Omstændighed, at de Maksima der iagttages for Vaadaalens Vedkommende for Limfiorden og vore indre Farvande, naar den beregnede Virkning af Temperaturen er

fradraget, ikke optræder tidligere end for Ruseaalens Vedkommende. De paa Fig. 20 anførte Kurver viser, at disse Maksima indtræder samtidigt for Ruseaalens og for de gennemsnitlig yngre Vaadaal. Der er da bl. a. Mulighed tilbage, at de nævnte Maksima i Hovedsagen kan skyldes den Omstændighed, at Fiskeriet har været drevet med forholdsvis stærk Intensitet i de paagældende Perioder. At noget saadant sandsynligvis har været Tilfældet i Ringkøbing Fjord i Aarene 1898—1900, er omtalt andetsteds [1]).

E. Den praktiske Betydning af de foretagne Undersøgelser.

Af de indvundne Resultater af de foretagne Undersøgelser er der i det mindste et, der vil kunne udnyttes i praktisk Retning, nemlig det, at Fangsten af Ruseaal i Efteraarstiden kan ventes at blive adskillige Procent højere end normalt for hver Grad Middeltemperaturen for August er over det normale. Viser det sig, at Temperaturen i August er forholdsvis høj, bør Fiskerne i særlig Grad søge at udnytte Chancerne for en stor Fangst ved at tage stærk Del i Fiskeriet efter Blankaal. I Almindelighed vil Fiskerne jo nok i nogen Grad selv kunne bedømme, hvorvidt Augusttemperaturen paa et givet Sted er forholdsvis høj, men de bør her have Støtte fra en organiseret Tjeneste til Meddelelse af Temperaturanomalierne. Da ogsaa en høj Julitemperatur i nogen Grad synes at virke fremmende paa Mængden af Blankaal, og da der gerne er en vis Overensstemmelse mellem Julitemperaturen og Augusttemperaturen, bør der offentliggøres ugentlige Oversigter over Temperaturen i Forhold til Normaltemperaturen allerede fra Begyndelsen af Juli, og disse Oversigter bør vedvare til Slutningen af August. Saadanne Meddelelser vil sikkert let kunne offentliggøres i de ugentlige Fiskeritidskrifter ved et Samarbejde mellem disse og de meteorologiske Institutter.

[1]) A. C Johansen: Om Forandringer i Ringkøbing Fjords Fauna p. 124. Mindeskrift for Japetus Steenstrup. København 1914. Bd. II.

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